DESIGN AND CONSTRUCTION OF CABLE PRESSURIZATION

CONTENTS

1. GENERAL

1.01 This section is intended to provide REA borrowers, consulting engineers, contractors and other interested parties with technical information for use in the design and construction of REA borrowers' telephone systems. It discusses in particula the design and construction of a telephone cable pressurization system in which the pressure is supplied by continuous feed dry air injection.

2. APPLICATION

2.01 Cable pressurization employing the continuous feed dry air injection method should be considered where the estimated annual cable maintenance saving approaches the annual charges on the necessary capital investment. Pressurization by this method can be expected to reduce the cable maintenance costs by

about twenty-five percent chiefly by the elimination of overtime work. Pressurization also can be expected to reduce the number of subscriber trouble reports due to trouble in paper-insulated cable* to about twenty-five percent of the number that would result without this protection. This reduction cannot be equated into dollars but is an important consideration in a study of pressurization. The need for pressurization is much greater for paper-insulated than for polyethylene-insulated cable because the polyethylene insulation is impervious to moisture whereas moisture in paper insulation causes circuit trouble. Experience shows that about 75 percent of all aerial paper cable trouble occurs in cables of 100 pairs or less. This makes it desirable to consider pressurization in exchange areas which have a preponderance of small size paper cable. Paper cables having air-tight strand mounted terminals or splice cases can be pressurized readily at minimum expense. Pressurization also should be considered for toll and trunk cables and cables to important places such as airports and military establishments whether the cables are aerial, in underground ducts or buried, and whether paper or plastic insulated. Pressurization should extend the life of lead cable by five to ten years.

2.02 Factors that must be considered in deciding for or against pressurization include the amount, size and type of cable and whether it is aerial, in underground ducts or buried. It is doubtful that pressurization will prove to be economical for an exchange having very much less than 15 sheath miles of aerial paper cable or for any polyethylene-insulated exchange cable. Addendum A details the estimated cost for pressurizing a cable system having 15 sheath-miles of aerial lead-sheath cable at a total cost of $4,950. The central office pressurization equipment of small size suitable for a maximum of 25 miles of sheath or less will cost about $1,000 installed. The tools required for the installation of plugs, pressure testing, valves, by-passes and for the initial leak testing will cost about $350. The installation of plugs, pressure testing valves and by-passes will cost about $140 per sheath mile of cable. The initial leak locating will cost about $100 per sheath mile or less. Of this amount, about $3,450 is capital expense and $1,500 is maintenance. About $350 of the expense is for items which would be required in future maintenance work.

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*The terms "paper-insulated" or "paper cable" as used herein include cable with either paper strip or paper pulp insulation.

2.03 Analysis of the data given in Addendum A indicates that a pressurization installation would be justified assuming that about two cable troubles per mile per year can be expected in aerial lead-sheath paper-insulated cable and that the cost for repairs would be about $50 per trouble. Assume:

Depreciation of pressurization equipment	5% per year
Interest on investment	5% per year
Total Annual Charges	10% per year

On a capital investment of $3,450 this gives annual charges of $345 per year. If the cable troubles are two per mile per year before pressurization the 15 miles of cable would have 30 troubles at a cost of $50 per trouble or $1,500 per year. If the reduction in maintenance cost is 25 percent, the saving per year would be 1/4 of $1,500 or $375 per year. This, compared to the annual charges on the installation at $345 per year, justifies the installation after the initial maintenance costs, particularly when the intangible advantages are taken into consideration.

2.04 In a group of exchanges of an operating company some exchanges will have insufficient aerial paper cable to justify pressurization, but if one or two do have enough such cable to justify pressurization, the time saved in their cable maintenance can be used to advantage in cable maintenance at the nonpressurized exchanges. The result should be better overall cable maintenance perhaps at no increase in total cable maintenance cost.

2.05 Methods have not yet been developed for pressurizing buried polyethylene-insulated cable in exchange distribution plant which uses terminal housings for above ground appearances. The presently available terminal housings are too small to accommodate the arrangements necessary for cable pressurization.

2.06 Pressurization cannot be applied economically to polyethylene-insulated aerial cables which use ready-access enclosures because of the cost of providing for air passage around these enclosures. It is estimated that such by-passes cost about $5 each and average about four per mile.

2.07 Pressurization equipment large enough to pressurize 25 to 100 sheath miles of cable will cost $300 to $400 more than the small size unit. The initial cable sheath leak clearing will be about the same per mile of sheath in both small and large projects.

2.08 In exchanges that do not have enough cable to justify continuous pressurization, the cable can be tested by using cylinders of O. P. nitrogen gas* applied temporarily. The procedure for this type of testing is described in REA Telephone Operations Manual, Section 1356.3, "Leak Locating in Telephone Cables by Spray Test."

3. PRESSURIZATION PRINCIPLES

3.01 Cable is pressurized to reduce service interruptions and maintenance costs due to moisture damage to cable conductors. This is accomplished by maintaining positive pressure inside of the cable sheath to prevent entrance of moist air or water at sheath cracks or breaks and to assist in locating such damage. The cable pressurization system presently preferred is called the "continuous feed" or "continuous flow" system. It employs commercially available equipment which automatically compresses and drys air and injects it into sheath cables at a controlled pressure. The dry air flow in paper cable tends to improve its insulation resistance by absorbing moisture that may have been in the cable at the time of pressurization. The compressor-dryer equipment for exchange cable usually is located in a central office. Pole mounted equipment also is available for such use as at an isolated submarine cable for intermediate locations on long toll cables, and for mounting on the exterior wall of a central office where space for it inside the building is not available. The dry air is injected into underground and burial cables at a pressure of about nine pounds per square inch (psi) and at least six psi in aerial cables. The lower applied pressure in aerial cables allows for expansion of the air in the cables during high daytime temperatures without creating excessive internal pressures which can cause the larger sizes of lead sleeves to swell. For example, a pressure of 1.9 psi in a cable at 3am may rise to 2.9 psi at 3pm with a variation of temperature from 50° to 70°. At least 2 psi is desired at the distant ends of the exchange cables although a pressure as low as 1 psi will prevent entrance of moisture. Ten miles or more of exchange service types of paper cable in one run can be pressurized from one location. It is customary to consider five to eight miles the maximum length for paper toll or trunk cable pressurization from one location. Polyethylene-insulated cable can be pressurized for considerably greater distances than paper cable from one pressure source.

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*O. P. nitrogen gas is "Oil Pumped Nitrogen Gas," a specific grade of dry nitrogen gas.

3.02 Evidence of leaks in the sheath of cable under pressure is given by excessive flow of air into the cable from the compressor unit; by the check of pressure at test valves spaced along the cable; and in exchange cable by operation of contactor devices which, in case of pressure failure, place a 270,000 ohm resistance across a subscriber line cable pair. The lines used by the contactors must be tested periodically from the central office to determine whether or not the pressure has failed and the resistance has been connected across the line at the contactors. This brief use of the lines is the only effect on their service. These line tests may be necessary as often as daily or as infrequently as monthly depending on weather conditions.

3.03 Pressurization will detect and permit the locating of lead sheath crystallization, ring cuts, porous solder work, electrolysis and other corrosion, et cetera, which are not accompanied by conductor mechanical damage. Pressurization also will indicate major sheath damage such as by bullets, fire, electrical burns, et cetera, occurring to either lead or plastic sheath cable. The "initial" leak clearing mentioned in paragraph 2.02 is done after the application of pressure to the cables. Minor leaks do not permit much loss of air and usually are ignored in the initial cleanup work. It is not necessary to make cable "air-tight" before air pressure is applied. Only the leaks which interfere with maintaining pressure need be initially located and repaired. The last step in the construction work is the installation of the contactors, after the completion of the cleanup work.

3.04 Cold resin pressure "plugs" (dams) are required in stubs of non-airtight terminals; at junctions of paper and polyethylene-insulated cables if the latter may now or later use ready-access enclosures and are non-pressurized; at points along a cable at about one mile intervals to sectionalize the system for test purposes, with by-pass connections bridging the plugs to permit air flow and shutoff; and in central office entrance cables to block air flow into the tip cables.

3.05 Plugs can be made by sheath injection or sleeve injection of resin sealing compound. The diameter of the cable, tightness of the core, the distances to the nearest splice and the kind of sheath material determine which of the two methods should be used in a particular case. The sheath injection method can be used on lead sheath stubs of non-airtight terminals and on lead sheath cables up to 1-1/4 inch diameter. The sleeve injection method is used on larger lead sheath cables, cables with loose cores, cables with paper wrap around the core and on plastic-jacketed cables.

3.06 Pressure testing valves placed at intervals along an aerial cable, for example, about 1/4 mile permit pressure readings which can be plotted on a graph to assist in approximately locating a sheath leak. These valves can be placed on poles at a convenient height above ground, with copper, lead or plastic tubing connecting them to the cable sheaths.

3.07 A contactor such as mentioned in paragraph 3.02 can be attached 1,000 to 2,000 feet from the end of a cable and adjusted to place its 270,000 ohm resistance across a cable pair serving a subscriber line when the pressure falls below a predetermined figure, usually 2 psi. No immediate alarm is given by this operation. It is necessary to make a voltmeter or ohmmeter test of such lines periodically. Preferably, no open wire should be connected to the cable pair used for this alarm. Also, individual line rather than party line cable pairs preferably should be used. Only one contactor should be assigned to any one cable pair. Subscriber lines are used for the contactors to avoid use of cable pairs simply for alarm use and for ease of testing the pairs at the central office, particularly if the office has a "test train."

3.08 The rate of air flow through a cable depends on its type and size. From 50 to 70 percent of the volume of a paper cable is space which permits air flow. Different types of cable vary widely in their air flow (pneumatic) resistance. For a given number of pairs in a cable the resistance increases as the gauge number increases. For example, a 25-pair, 22-gauge paper cable has more resistance than a 25 pair, 19-gauge paper cable. As a result of the pneumatic resistance and the small leaks in a sheath, the pressure decreases as the distance from the air pressure source increases. The pressure may gradually decrease from the 6 or 9 psi at the source to a value not much above the 2 psi desired at the end of a cable. Therefore, a leak of a certain size will give greater loss of air if the leak is near the air source than if it is near the low pressure end.

3.09 Pneumatic resistance per thousand feet of cable is the measure of air flow through a cable. The volume of air that will flow through a cable decreases with increase of cable length and increases with increase in pressure. The pneumatic resistance of a cable can be determined only by test. Various types and sizes of cable can be related to a "basic" cable one inch in diameter and 1,000 feet long which arbitrarily can be considered as having 1.0 unit of pneumatic resistance. If one pound of air

pressure is applied at one end of such a paper cable, air will flow out the other end at one cubic foot per hour. Approximate total pneumatic resistance per 1,000 feet for typical exchange type paper cable, which data are useful in cable pressurization system planning, are given in Table 1.

TABLE 1

Cable Pneumatic Resistance *

No. of Pairs	Gauge of Conductors, Paper-Insulated Cable		
	19	22	24
	Total Pneumatic Resistance per 1,000 Feet		
16	15	40	50
26	10	25	40
51	6	15	20
76	4	10	16
101	3	7.5	13
151	2	5	10
202	1.5	4	8
303	1.0	3	5
404	0.8	2	4

* Divide these values by 5 for design work on polyethylene-insulated cable.

3.10 Definite and complete data for polyethylene-insulated cable of all sizes are not available. The results on sizes tested to date indicate that the values are considerably lower and more erratic for polyethylene-insulated than for paper-insulated cables of the same diameter or number of pairs, probably because of the erratic space fill and the smoother polyethylene surface of the wire. An approximation is that the pneumatic resistance of polyethylene-insulated cable is about 1/5 that of paper-insulated cable. This means, for example, that the definite monitoring range for a 50-pair, polyethylene-insulated cable will be about five times longer than for a 50-pair, paper cable.

3.11 The pressure contacting devices mentioned in paragraph 3.02 "monitor" the cable. One monitoring range is called the "definite" monitoring range. The other is called the "indefinite" monitoring range. The definite monitoring range is considered to extend in any direction from the contactor, in which a leak

within the range will cause the contactor operation in about eight hours or less. This range extends to a distance from the contactor to a pneumatic resistance of 20. The indefinite monitoring range extends back toward the source of the air pressure beyond the pneumatic resistance of 20.

3.12 The definite monitoring range of 20 requires a contactor to be adjusted to close its contact if the setting is 0.5 psi below the normal pressure at the contactor location. This normal pressure should be decided by taking at least three readings at the contactor location, preferably between 8 and 9am or 4 to 5pm. A large leak in a sheath between the contactor and the air source or in any branch of the feeder cable within the pneumatic resistance of 20 from the contactor will operate the contactor. If the leak is at a pneumatic resistance of more than 20 beyond the contact away from the air source, no contactor operation may result or it may result only after a long period of time. If the leak is between the air source and the contactor and at more than a pneumatic resistance of 20, the contactors will always operate but after an uncertain time which will depend on the pneumatic resistance to the leak. This time interval may be a matter of days.

3.13 A small leak in a small cable often is more damaging than the same size leak in a larger cable because the small cable is likely to be at a considerably greater distance from the air pressure source where the pressure probably will be much less. The reason is that the slow rate of air flow and low pressure in a small cable may permit negative pressure when the cable gets cold and this may allow moisture to enter the sheath even though it is pressurized. Therefore, the primary advantage of pressurization of the small cables of considerable length is for the assistance given in locating trouble rather than protection against moisture.

3.14 The capacity of the pressurizing equipment required depends on the number, size, type and sheath miles of cable to be pressurized. In estimating the capacity required it is safe to assume that ten cubic feet of air per day or less will be required per mile of cable sheath placed under continuous pressure. Cables in good condition normally will use considerably less than this amount of air.

3.15 One type of compressor-dryer commercially available drys the air by refrigeration. All of the compressing and drying equipment is in one cabinet. Room air is compressed, delivered to a storage tank, cooled to a sub-zero temperature and then expanded to the pressure desired for application to the cables. The air passes through a small desiccant tower which drys the air during the short defrost cycle. This tower is self-reactivating and the

desiccant does not have to be changed. These actions condense and remove about 98 percent of the moisture in the air at 70°F. The cabinet has an output pressure gauge and a humidity sensing device which gives an alarm if the humidity of the output exceeds a predetermined value. The moisture is condensed and the resulting water automatically discharged into a drain or pail. A small unit may discharge as much as a gallon of water per month in very humid weather. This type of compressor-dryer has high pressure and output pressure gauges, a temperature gauge and humidity alarm, and is available in a small 250 cubic foot per day size.

3.16 Other available types of compressor-dryer equipment use desiccant instead of refrigeration for drying the air. Certain of these use a desiccant container which requires a replacement of the desiccant every six to eight months. The compressor is in the same cabinet as the dryer unit in one available small size unit. The compressor and dryers are separate units in some larger models. These models all include output pressure gauges and humidity alarms. These types of compressor-dryers also remove about 98 percent of the humidity from the air then deliver at 70°F. The smallest size unit of this type presently available has a capacity of about 250 cubic feet per day.

3.17 Cables can be pressurized readily if they do not have "filled" splices; that is, splices filled with paraffin, resin or other solid compounds which will block the air flow through them and if they do not use ready-access enclosures. Filled splices and ready-access enclosures will require by-pass tubes. Ready-access enclosures also will require "plugs" on each side of them.

3.18 Air feed to the individual cables is supplied through air flow indicators at the pressurizing equipment location. A gas meter is installed in the main air feed to the air flow indicators. The air flow indicators show the rate of air flow to the individual cables and the gas meter shows the total flow to all the group of cables served by the air flow indicators. These devices, together with the pressure contactors, give indications of serious leaks.

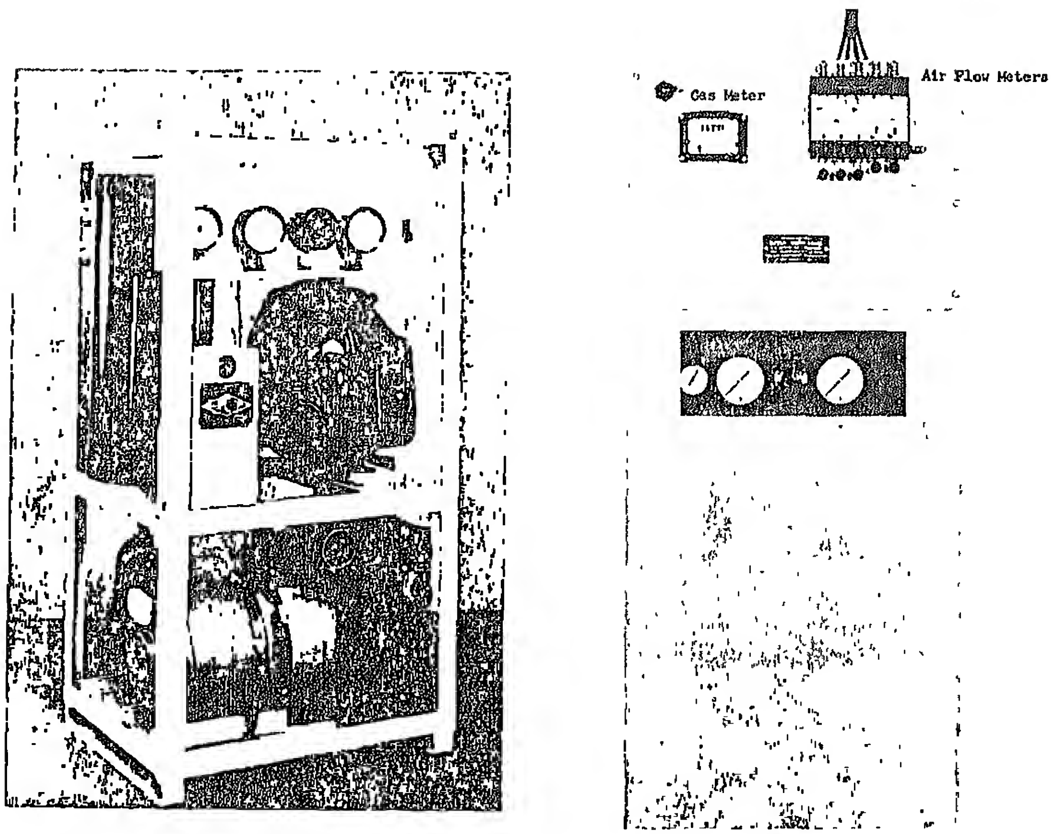
3.19 Cable trouble made evident by the low pressure at a pressure contactor or by excessive air flow at the central office can be traced down to a section of cable between by-pass valves by taking pressure readings at pressure testing valves. A chart made of these readings will show the approximate leak location. The preparation of such a chart is described in paragraph 13. If the section is aerial cable, the leak can

be found by use of a portable spray leak detector which causes bubbles at a leak. This is a three-nozzle device which can be attached to the end of a jointed pruner pole, connected by plastic tube to a tank of water-concentrate solution under pressure. The tank has its own pressure pump for manual operation and the tank can be carried in a harness on the tester's back. The tank also can have the pressure supplied through a tube from a small cylinder which contains O. P. nitrogen gas. The tank has a valve for attachment of this tube. Control of the spray is by hand-operated valve. The two tanks are carried on a two wheel cart. The tank without the gas cylinder is suitable for use in rural areas where the terrain prevents the use of the cart. Leaks in underground cables in manholes also can be located by the spray test method. The solutions used in spray testing of cables differ for plastic and lead-sheath cable. The solution used for lead cable is damaging to polyethylene sheath. For lead-sheath cable one type of solution is necessary if the temperature at the time of testing is above 32° and a different solution if below 32°. This method of leak locating is described in detail beginning at paragraph 12.09.

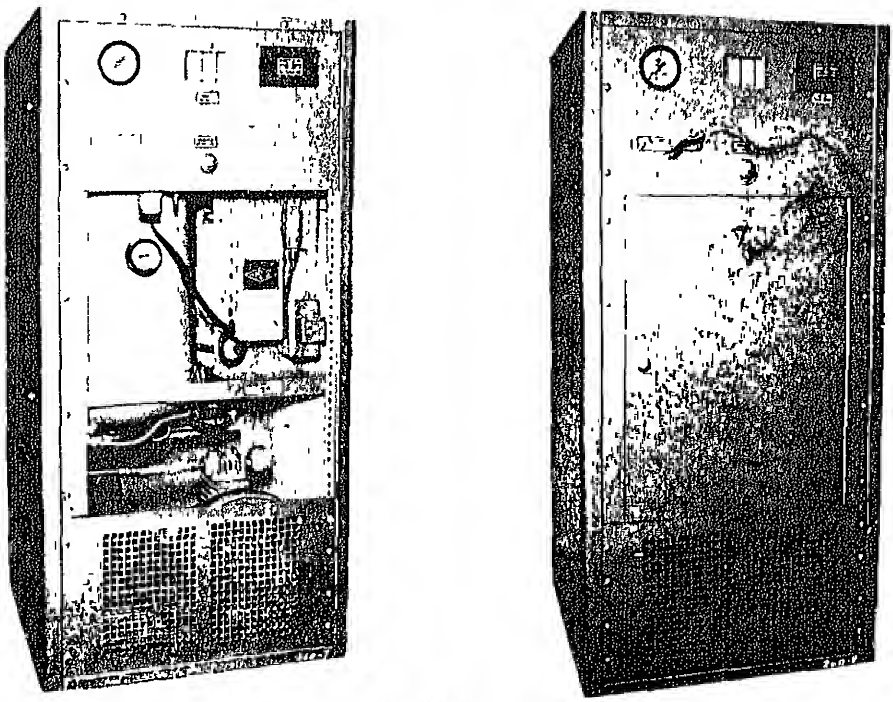
4. PRESSURIZATION EQUIPMENT (See Figure 1)

4.01 Compressor-dryer equipment, air flow indicators, gas meters, valves, contactors, et cetera, are commercially available products. A typical compressor-dryer unit capable of continuously producing about 250 cubic feet of air per day can be operated on 115 volts, 60 cycle, single phase power. It will require less than 10 amperes of current. They should be capable of producing air pressure up to 15 psi and have adjustable high and low pressure alarms. The guaranteed humidity of the delivered air should not exceed two percent at 70°F. Such units will occupy six square feet or less of floor area for the compressor and dryer equipment. A drain pail, if used, is external to the compressor-dryer unit.

4.02 The air flow indicators mentioned in paragraph 3.18 are available in units of 3, 5 or 10 mounted on a manifold. These indicators and the gas meter are on a panel designed for wall mounting. Each indicator includes a shut-off valve mounted beneath it to stop air flow in a badly leaking cable or one that is being opened up by splicers. Splice openings might overload the compressor. Each indicator also has a pressure testing valve at its top. If more than ten cables are involved, two or more units of indicators can be used, each unit of ten indicators having its own gas meter. Plastic tubing is used to connect each indicator to a cable that is



PUREGAS EQUIPMENT CORPORATION - MODEL 600



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TYPICAL COMPRESSOR DRYER UNITS

Figure 1

to be pressurized. A shut-off valve should be in the main air feed line from the dryer to the air rate indicator units. Each air rate indicator should be the type that contains two balls, one of which is black plastic and the other stainless steel in a glass tube with the black ball above the steel ball. Normal air flow will lift the black ball. Abnormal air flow will lift both the black and the steel balls. The glass tube is graduated on one side for the black ball and on the other for the steel ball. One scale, for low pressure, gives flow rate indicated by the black ball position. The other is a higher pressure scale which shows the flow rate indicated by the steel ball position. The low pressure scale has a sliding pointer which can be set at a point of normal flow. The scales indicate the flow rates in cubic feet per hour.

4.03 Pressure testing valves spaced along a cable are similar to the valves on an automobile tire. They permit taking pressure readings by means of a gauge designed for the purpose. They also permit injection of O. P. nitrogen gas from cylinders in emergencies such as when the compressor-dryer unit fails or when an opening is to be made in a cable sheath and it is considered desirable to maintain as much pressure as practicable in the opened cable. Pressure testing valves usually are located at riser poles if there is any considerable amount of underground cable between the aerial cable and the central office. From there out to the end of an aerial cable the valves are spaced about 1/4 mile apart. A valve is placed at the end of each branch cable if it exceeds about 500 feet in length. For buried cable the spacing of valves can be about 1/2 mile apart. A valve is a part of each pressure contactor. Valves can be attached to both lead sheath and the plastic sheath. The method of attachment to plastic sheath depends on the type of cable and whether it is aerial in underground duct or buried.

4.04 By-pass valves shown in Figure 2 are required to give a continuous flow of air around a pressure plug, a filled sleeve or a ready-access enclosure. Three types are available all of which include a shut-off valve. One type is a simple shut-off valve with two in-line projecting pipe tubes. The other two types called the Dual Stem By-Pass Valves have the shut-off valves plus two pressure testing valves, one of which is on each side of the shut-off point. The one not shown in Figure 2 has the two pipe tubes in line in a manner similar to the valve without the pressure testing valves in this figure. As it has two pressure testing valves it is desirable for mounting on a plug sleeve.

It has an advantage in that its control screw is visible when turned "on" and not visible from the ground when it is turned to the "off" position. The pressure testing valves are desirable on each side of a plug or filled sleeve to permit check of pressure in the cable in each direction when the by-pass valve is closed. Paragraph 8 describes the installations of these by-pass valves and the related pressure testing valves. The illustrated by-pass with the two pressure testing valves is used where buried cable is plugged underground. For this situation two tubes are brought up an adjacent stub pole to the by-pass. It also is used where aerial cable has a plug and the pressure testing valves are desired at the base of the pole. On an underground cable in ducts this dual valve is mounted on the manhole cover frame where it is readily reached when the cover is removed.

5. PRESSURIZATION TOOLS AND SUPPLIES

5.01 Pressurization tools and supplies indicated below and mentioned in various paragraphs herein are those which REA is aware of at present. The information is provided with the specific understanding that REA does not endorse or give advance approval to any persons or firms offering goods or services to its borrowers. There may be other such items unknown to REA which are available and suitable for use.

5.02 The installation of cable pressurization systems requires tools and supplies including those listed below: (See Figure 2)

<u>1/4 Inch Cable Drill</u> - For boring lead cable sheath or sleeves for C Pressure Testing Valve installation and for a hole at a B Pressure Flange on cable smaller than one inch diameter.

<u>1/4 Inch Cable Drill Bit</u> - Extras required.

<u>3/8 Inch Cable Drill</u> - For boring lead sheath on sleeves for D Pressure Testing Valve installation on cable over one inch diameter.

<u>3/8 Inch Cable Drill Bit</u> - Extras required.

<u>B Flange Clamps</u> - For holding C Pressure Flanges in place while soldering it to lead sheath or sleeve. Consists of a chain with a hook at each end and a spiral spring in the middle.

C Flange Clamps - For holding B Pressure Flange in place while soldering it to lead sheath only. Consists of a spring clip, one jaw of which has a pilot for holding and centering the flange over a hole bored in the sheath.

B Sheath Lifter - For raising lead sheath at sealing compound injection hole in cable over one inch diameter.

C Pressure Gun - For injecting sealing compound into cable through a D Pressure Flange. Capacity 300 grams of compound.

B Pressure Gun Holder - For supporting the C Pressure Gun while loading it. Attaches to pole on ladder.

C Adapter Nozzle - Permits use of C Pressure Gun at B Pressure Flanges. Required because of differences in threads of the flanges.

B Cable Core Depressor - For depressing cable core at injection hole.

B Cleaning Rod - For stirring sealing compound and for cleaning gun nozzle and adapter.

KS-16302 Cleaning Fluid - For cleaning pressure gun. Pint cans, non-flammable and not a solvent.

Orange Stick - For penetrating core to facilitate injection of sealing compound into cable.

B Pressure Flange - Brass fitting, solders to lead cable sheath up to one inch diameter over hole bored with 1/4 inch cable drill for injection of sealing compound by pressure gun. Inside threads are 1/4 inch United States Standard.

C Pressure Flange - Tinned bronze fitting, solders to lead cable sheath or sleeve, permits boring hole through sheath or sleeve with 1/4 inch cable drill. For supporting F Pressure Testing Valve, F Pressure Testing Ell or making a temporary vent. Inside threads are 1/8 inch pipe threads.

D Pressure Flange - Tinned bronze fitting, screws into 3/8 inch cable drill hole in lead cable sheath over one inch diameter or on lead sleeves, for making plugs by sealing compound injection. Also, for supporting B Pressure Ells at by-pass valve installations. Inside threads are 1/8 inch pipe threads.

C Pressure Flange Plug - Hexagon head brass screw for sealing C and D Pressure Flanges and B Pressure Ells. Has 1/8 inch pipe threads.

D Sealing Compound * - 100 gram (68 grams of resin and 32 grams of activator) for plugs in paper or polyethylene-insulated cable, with or without glass mill end fibers. The fibers are in separate plastic bag.

D Sealing Compound * - 300 gram (204 grams of resin and 96 grams of activator) for plugs in paper or polyethylene-insulated cable, with or without glass mill end fibers.

Kerodex 71 Protective Hand Cream - 4 ounce tubes (available at drug stores) water repellent, for application to hands before making sealing compound plugs.

Kerodex 51 Protective Hand Cream - 4 ounce tubes (available at drug stores) washable, for application to hands over application of Kerodex 71.

C Pressure Testing Valve - For mounting on lead cable sheath or sleeve. Screws into hole bored with 1/4 inch cable drill.

F Pressure Testing Valve - For mounting on metal splice cases or on C and D Pressure Flanges on lead cable sheath or sleeve. Has 1/8 inch pipe threads.

Valve Repair Tool - Threads C Pressure Testing Valves into 1/4 inch cable drill hole in lead cable sheath or sleeve.

C Pressure Gauge - With 18 inch chuck ended rubber hose and leather carrying case, tests 0 to 12 psi. Chuck permits application to pressure testing valves.

By-pass Valve - For isolating a section of cable by blocking air flow in a plug by-pass; designed for lashing to cable strand or sleeve.

Dual Stem By-pass Valve - For isolating a section of cable by blocking air flow in a plug by-pass. Designed for mounting on pole or in manhole.

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*If the sealing compound is for use in polyethylene-insulated cable, the compound is ordered with "Glass Mill End Fibers" which are supplied at no extra cost.

B Pressure Testing Ell - For by-pass connections at plugs or filled sleeves by means of lead pipe and by-pass valves, has an F Pressure Testing Valve on one end, has 1/8 inch pipe threads to fit C or D Pressure Flanges and flanges of splice cases.

Pressure Testing Ell - Solders to lead cable sheath or sleeve in hole bored by 1/4 inch cable drill, also solders to 1/2 inch OD lead pipe for by-pass connections where pressure testing is unnecessary, as at a filled sleeve.

Male Elbow, 1/4 Inch - For attaching 1/4 inch OD plastic tubing to a C or D Pressure Flange on cable. Dekoron EZ Fitting No. P6-4-2 or equivalent. Has 1/8 inch pipe threads to fit flange threads.

Street Elbow, 1/8 Inch - Has 1/8 inch male threads at one end for threading into C or D Pressure Flanges or into splice case flanges, with 1/8 inch female threads on other end. For use at flanges in the side of cable or splice case to permit pressure gun to be vertical.

M Pressure Testing Valve Cap - Hexagon shape for tightening with wrench to prevent tampering.

Soldering Form 1/2 Inch Round - For use in soldering flanges to lead cable sheath or sleeve.

Cable Mounted Contactor - Type M or United Electric Controls Company Type J31-5333 Pressure Guard or equivalent.

Pole Mounted Contactor - Type L or United Electric Controls Company Type J31-5338 Pressure Guard or equivalent.

Lead Pipe, 1/4 Inch ID, 1/2 Inch OD - For connecting by-pass valves to pressure testing ells.

Lead Lashing Wire - AT6634 or Equivalent - For lashing lead pipe and by-pass valves to strand and cable.

Plastic Tubing, 3/8 Inch OD - For use from compressor-dryer to air flow meter panel in central office.

Plastic Tubing, 1/4 Inch OD - For use from air flow meter panel to individual cables in central office.

Connector, 1/4 x 1/8 Inch - For connecting 1/4 inch ID copper tubing to air flow meter panel and to compressor-dryer.

Pipe Joint Compound - "Pipetite-stick" or equivalent--for application to all threads at threaded connections.

O. P. Nitrogen Gas, 224 Cubic Foot Cylinder - For supplying pressure to cable at time of initial pressurization and for charging 25 cubic foot cylinders.

O. P. Nitrogen Gas, 25 Cubic Foot Cylinder - For supplying pressure to 4-1/2 gallon tank in spray testing work. Charged from 224 cubic foot cylinder through Cylinder Charging Connector.

Cylinder Charging Connector - For charging 25 cubic foot cylinders with O. P. nitrogen gas from a 224 cubic foot cyliner.

Tank Carrier - Cart for carrying 4-1/2 gallon spray solution tank and 25 cubic foot O. P. nitrogen gas cylinder.

Pressure Regulator, Airco Style 8429, AT6656 or Equivalent - For reducing pressure output of 224 cubic foot O. P. nitrogen gas cylinder when injecting gas into cable.

Plastic Tubing - Equipped with fittings for attachment to 224 cubic foot O. P. nitrogen gas cylinder and to a pressure testing valve, 25 foot length.

Flash Leak Tester - For testing valves and cable splicing work, with finger-operated pump for spraying water-concentrate solution.

Winton One-Wheel Roll Sprayer - Three nozzle sprayer with 4-1/2 gallon tank for water concentrate solution, fluid line, hand pump and carrying harness--for spray testing aerial cable.

Fiberglas Pruner Pole - Three six foot sections and one three foot section.

Spray Drip Deflector - Synthetic rubber disk for placing on pruner pole while spray testing.

C Pressure Testing Concentrate - For use on lead cable at temperatures above 32°F.

B Pressure Testing Concentrate - For use on polyethylene sheath cable at temperatures above 5°F.

D Pressure Testing Concentrate - For use on lead sheath cables at temperatures between 5° and 32°F.

Splicing Materials - As required for making tape-wrapped joints between a lead sleeve and polyethylene sheath as described in REA Standard Specification PC-3, "Straight Splicing Thermoplastic - Insulated, Thermoplastic-Sheathed to Paper-Insulated, Lead-Sheathed Cables Used on Telephone Systems of REA Borrowers."

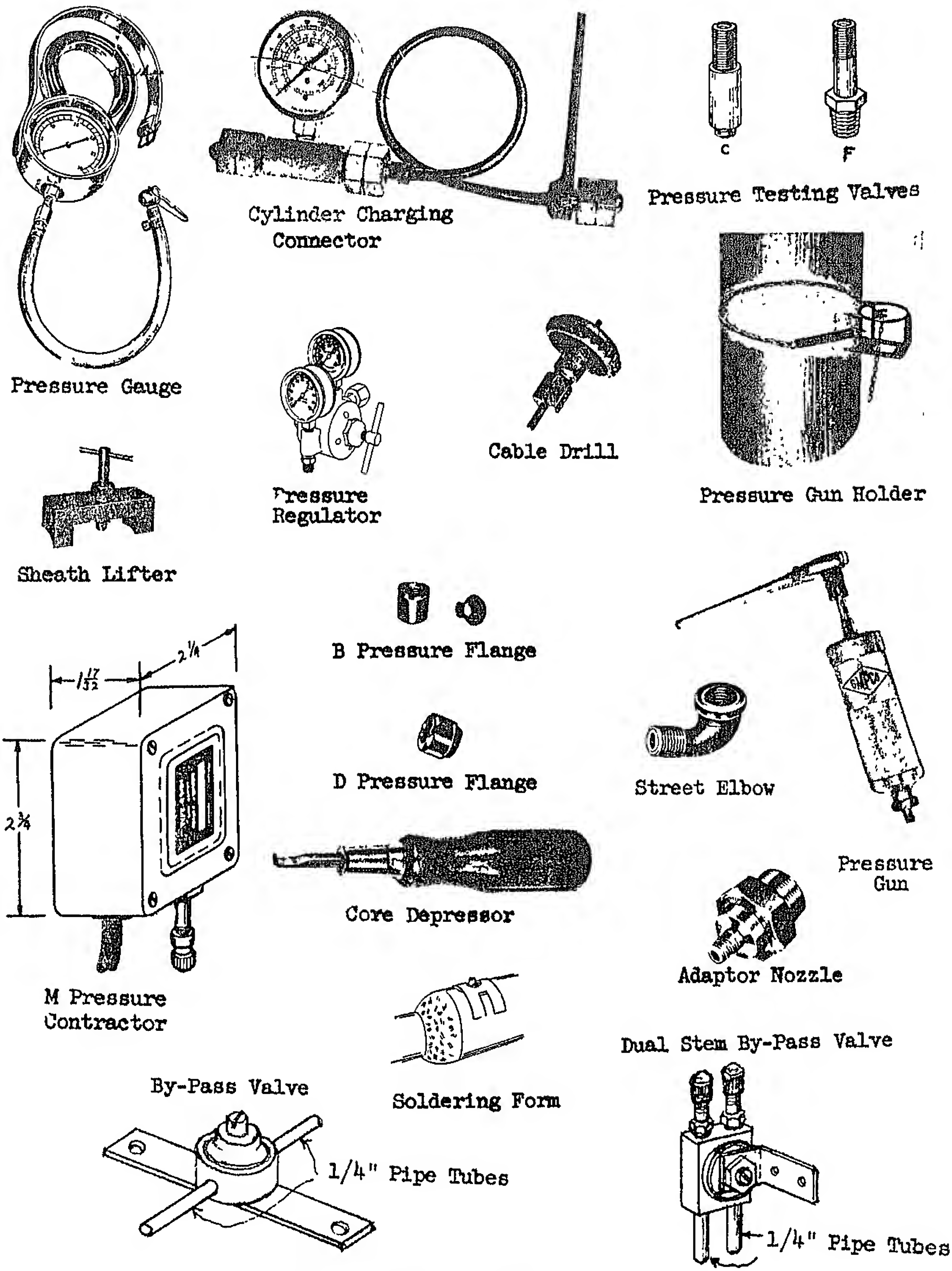
6. CABLE PLUGGING PROCEDURE

6.01 Cable plugs can be made successfully by methods and with materials other than described herein. The methods suggested in the following paragraphs have been in use a few years with satisfactory results. The methods not described herein make use of other types of pressure guns and resin compounds. Resin compounds for certain of the other guns are packaged in plastic containers that they cannot touch the operator's hands and thus the use of the protection hand creams are not required.

6.02 Pressure plugs preferably should be made in cable before air pressure is applied. If the cable is under pressure, it is necessary to vent the cable on each side of the plug location during the plugging operation. This can be done by opening pressure testing valves nearby, by drilling temporary holes in the sheath or by making temporary openings in nearby sleeves. Non-airtight distribution terminal stub plugs should be made before the cable is under pressure, otherwise the stub should be vented temporarily near the sleeve.

6.03 Sheath Injection - Lead-Sheath, Paper-Insulated Cable

6.031 Lead-sheath cables and terminal stubs less than 5/8 inch diameter are plugged by injecting resin compound through a B Pressure Flange soldered to the sheath over a hole bored with the 1/4 inch cable drill. Two adjacent B Pressure Flanges are required for cables 5/8 to one inch diameter. Cables larger than one inch diameter require two of the D Pressure Flanges for which the 3/8 inch cable drill is used. Where two flanges are required they are spaced about six inches apart and one is around the cable circumference 90 degrees from the other one. These can be placed in vertical, horizontal,



TYPICAL TOOLS AND DEVICES

Figure 2

or curved cables. Plugs in aerial cables should be at least 30 inches from a splice or from where one may be placed later. Plugs in terminal stubs should be made 12 to 18 inches from the nearest splice to prevent the resin mixture entering the splice.

6.032 For plugs in the 5/8 inch or smaller lead cables, the sheath is cleaned with a carding brush and coated with stearine after which a hole is bored using the 1/4 inch cable drill. The core then is depressed using the cable core depressor and the sheath is raised slightly and any burrs are removed. The core wrapping paper then is removed at the hole by punching through it with tweezers, making closely spaced punch holes so that the paper can be removed. The core then is penetrated carefully with the orange stick lubricated frequently with stearine, using care not to damage conductor insulation. A type B Pressure Flange then is cleaned and coated with stearine, put in place and held by a C Flange Clamp. It then is soldered to the sheath.

6.033 For plugs in the 5/8 to 1-1/4 inch diameter lead cables, the procedure is similar to that stated above for small cable as to cleaning the sheath and boring the holes. The holes are bored with the 1/4 inch cable drill. On cables of one inch diameter or smaller, the core is depressed and the sheath raised about 1/16 inch with the core depressor. This method of plugging also may be used on lead cables larger than 1-1/4 inch diameter where conditions prevent the application of a lead sleeve. The core wrapping paper is removed in the hole by punching through it with tweezers, making closely spaced holes so that the paper can be removed. The D Pressure Flange is screwed into the hole using the Valve Repair Tool. The flange then is soldered to the sheath and on cables larger than one inch diameter and the sheath is raised using the B Sheath Lifter.

6.034 After a pressure flange has been soldered to a lead sheath, the D Sealing Compound can be injected using the C Pressure Gun. Pressure plugs preferably should be made at temperatures above 45°F. At temperatures below this value, it is necessary to keep the sealing compound and pressure gun in a warm place until used and the cable sheath must be warmed by torch before injection is made. The large charge can of resin for the compound is not completely filled and has vacant space enough to hold the

activator liquid. The small charge unit of D resin and D activator can be mixed in the pressure gun. The two ingredients are mixed with a B Cleaning Rod, stirring for at least one minute. Then the rod is cleaned to prevent the mixture drying on it. The edge of the can is squeezed with eight inch pliers to form a pouring spout. The cap and plunger are removed from the pressure gun and the mixture is poured into it. The plunger is inserted in the gun at an angle to avoid trapping air in it. The cap is screwed on to hand-tight fit. The gun then is screwed into the pressure flange. The mixture is squeezed slowly into the cable by turning the pressure gun ratchet wrench handle. For injections in cables that require more than one charge, successive charges are made five minutes apart except the final one which should be made 15 minutes after the previous one. The piston must not be withdrawn while the gun is attached to a flange. After the final injection a screw plug is inserted in the flange. If the flange is on the side of a cable, a 1/8 inch street elbow is used temporarily so that the gun can be held vertically while injection takes place. The gun must be cleaned promptly, otherwise the mixture in it will harden and be difficult to remove. Where two flanges are used, the compound is injected into one and then the other, alternately, keeping the unused flange plugged (hand-tight fit) to prevent escape of plugging compound. It is necessary to use a C Adapter Nozzle with the C Pressure Gun when injections are made into B Pressure Flanges because the threads of the gun fit the D Pressure Flange but not the B Pressure Flange.

6.035 The resistance to turning of the handle of the pressure gun will indicate when the cable is filled sufficiently. If the ratchet handle cannot be turned any more after a short interval, it is due to the cable being filled. The quantities of sealing compound required per plug for various diameters of cable using the C Pressure Gun are given in Table 2.

TABLE 2

D Sealing Compound Requirements
For Lead Sheath Injection

O. D. of Cable Inches	Number of Small* Charge Injections	Number of Large** Charge Injections
.32 to .65	1	
.65 to .73, Inclusive	2	
.74 to .83, Inclusive	3	1
.84 to .90, Inclusive	4	
.91 to .99, Inclusive	5	
1.00 to 1.16, Inclusive		2
1.17 to 1.35, Inclusive		3

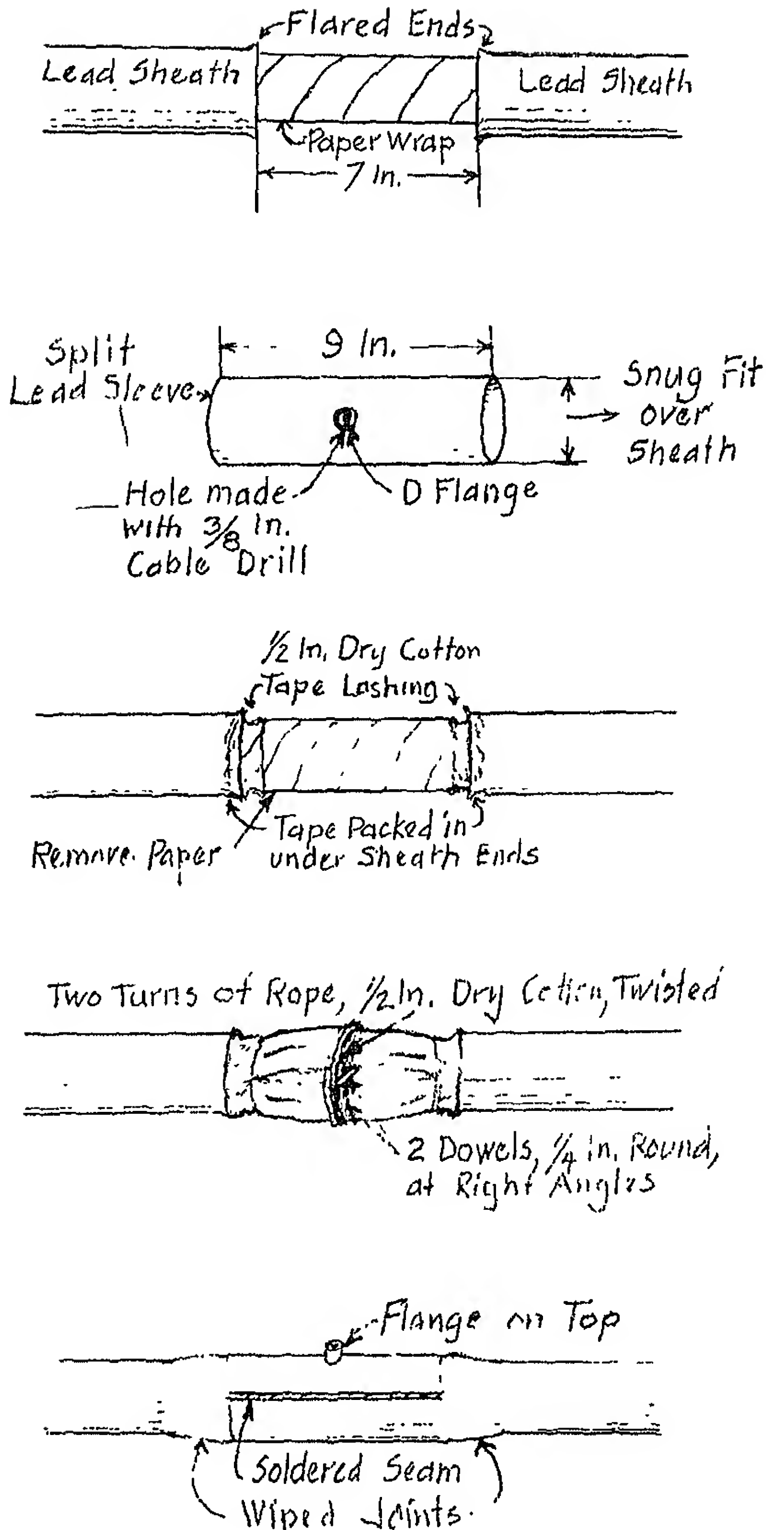
*Small Charge consists of:
1 - 68 gram tube of resin
1 - 32 gram tube of activator

**Large Charge consists of:
1 - 204 gram can of resin
1 - 96 gram tube of activator

6.04 Sleeve Injection - Lead Sheath, Paper-Insulated Cable

6.041 The sheath injection methods should be used for plug making for lead-sheath cables up to 1-1/4 inch diameter. The sleeve injection method should be used for all sizes of lead-sheath cables exceeding that diameter. This type plug can be made in vertical or horizontal cables. A plug should be at least 20 inches from any splice and that far from any possible future splice. Otherwise a plug can be made anywhere in a span. (See Figure 3)

6.042 For a sleeve injection in a horizontal cable, about 7 inches of the lead sheath is removed exposing the paper core wrap. The sheath ends are flared out slightly and dry 1/2 inch cotton tape is lashed around the paper wrap at each end of the opening and packed into the sheath flares. The core paper wrap is removed between the cotton tape wraps. The binding strings on the conductor units or bundles are cut and removed. The core is probed through, using the orange stick, first vertically and then horizontally to balloon the core. Two dowel pins 1/4 inch in diameter are inserted through the core, one vertically and the other horizontally, of length equal to the diameter of the ballooned core. Dry 1/2 inch cotton tape is then tied around the core about where the dowels are placed. A close-fitting lead sleeve is selected, usually about 2 inches longer than the sheath opening. The D Pressure Flange is attached



Sleeve Injection - Lead Cable over 5/8 In. Dia.

Figure 3

to the sleeve at midpoint. The lead sleeve is sawed lengthwise and the saw burrs are cleared off. The sleeve is opened up enough to permit placing it over the cable sheath, then closed up and the seam soldered. The sleeve is placed so that the flange is on the top of a horizontal sleeve. The sleeve is then wiped to the sheath in the same manner as any lead splice sleeve. The sealing compound then can be injected. The quantities of compound required are given in Table 3.

TABLE 3
D Sealing Compound Requirements
For Lead Sleeve Injection

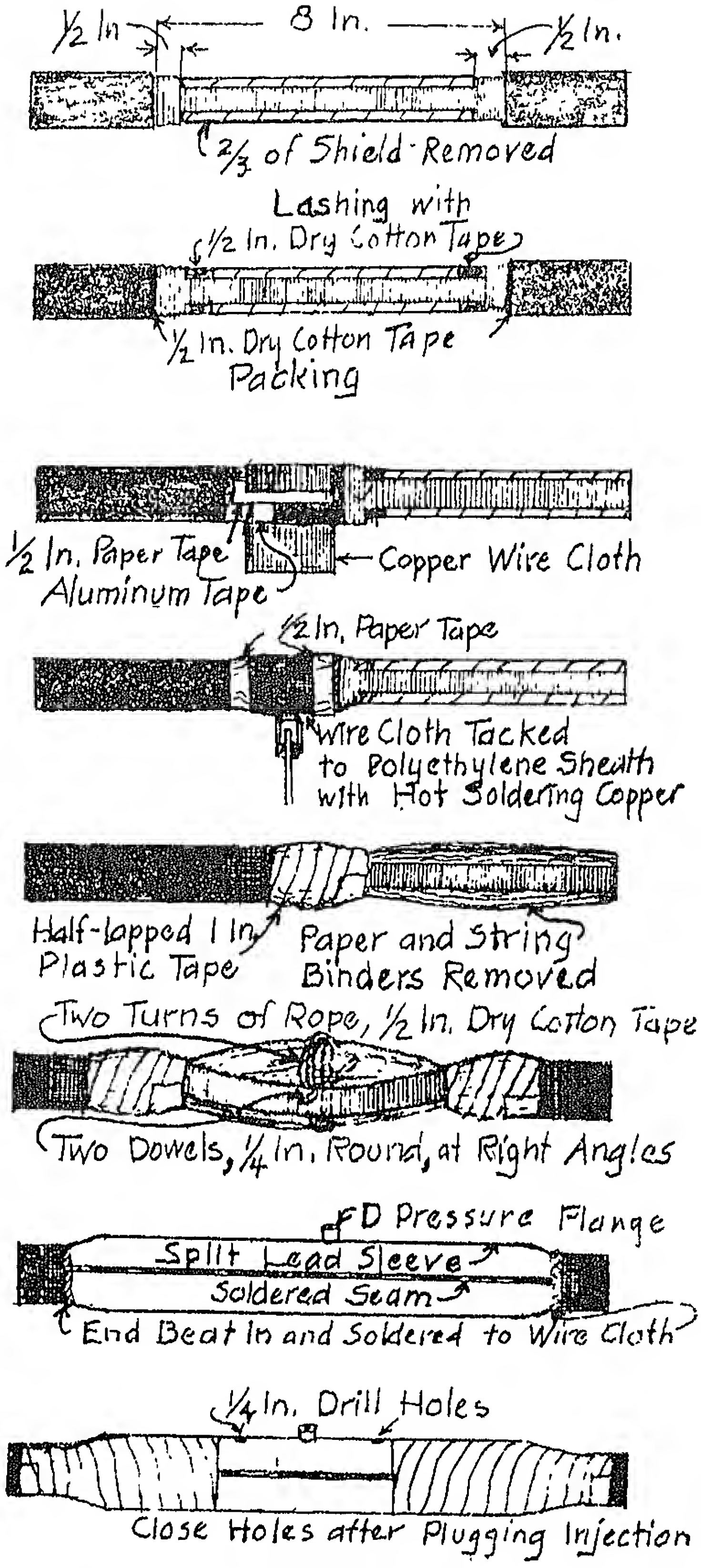
O. D. of Cables-Inches	Number of Large Charges*
.65 to 1.2	1
1.2 to 1.6	2
1.6 to 2.0	3
2.0 to 2.25	4
Over 2.25	5

*Large Charge
1 - 204 gram can of resin
1 - 96 gram tube of activator

6.05 Sleeve Injection - Plastic-Sheath, Paper-Insulated Cable

6.051 The sleeve injection method for making plugs should be used for all sizes of plastic-sheath, paper-insulated cables. These include the so-called Alpeth and Stalpeth types of cables. The various types of plastic-sheath cables may have polyethylene or polyvinyl sheaths. Such cables may have either longitudinal or spiraled shields. The procedure for providing access to the core of cables having spiraled shields may necessitate cutting the shield, which will require a bridging metallic bond across the opening soldered to the shield to give electrical continuity to the shield. Otherwise, the sleeve plug can be made as described below for cables with longitudinal shields. (See Figure 4)

6.052 The lead sleeves used in this method of plugging are joined to the plastic sheaths in the manner and with the materials and tools described in REA Standard Specifications PC-3 mentioned in paragraph 5.02 under "Splicing Materials."



Sleeve Injection - Plastic-Sheath, Paper-Insulated Cable

Figure 4

One difference is that the "end seal" shown in Figure 2 of PC-3 is omitted. As in the case with the sleeve method of plugging lead-sheath cable, the lead sleeves can be used for cables either in horizontal or vertical positions provided the location is not at a bend in the cable. The locations of the plugs should be the same as mentioned for lead-sheath cable plugs.

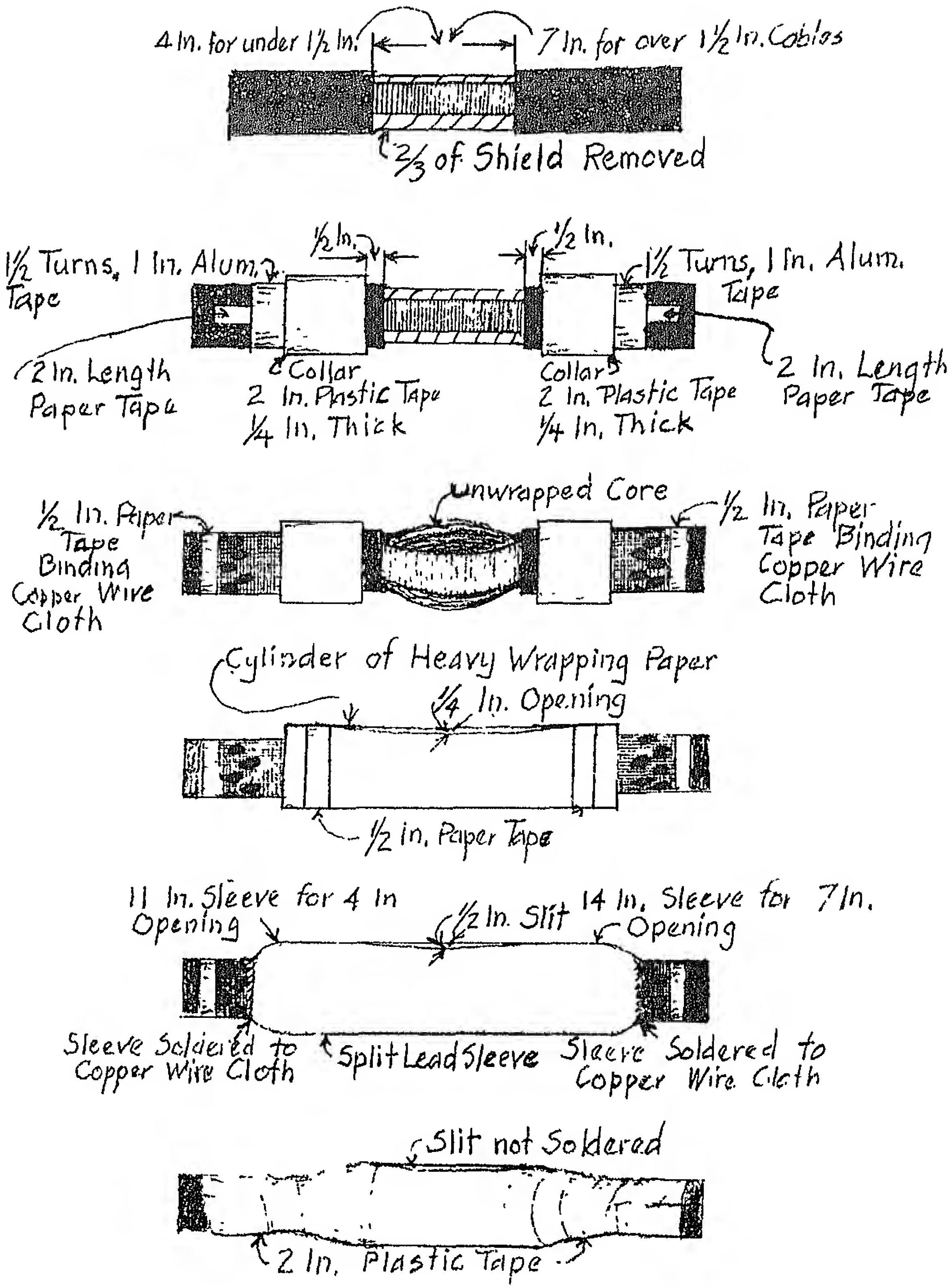
6.053 The sheath openings for plastic-sheath cable having no inner extrusion of plastic can be about 8 inches long. The metal shield is cut lengthwise with two parallel cuts about 1/3 of the cable circumference apart. The metal is removed in the 2/3 part and left intact in the 1/3 part to permit the necessary electrical continuity of the shield. The strip of metal that remains is stretched slightly to permit ballooning the conductors. Dry 1/2 inch cotton tape is packed between the sheath and core; also between sheath layers to prevent spread of sealing compound into the cable beyond the opening. Dry 1/2 inch cotton tape is lashed around the core at the ends of the opening. The core wrapping then is removed, the core is ballooned and two 1/4 inch diameter wood dowels are placed through the core as described in paragraph 6.042. Two turns of rope made by twisting dry one inch cotton tape are then placed around the core under the strip of shield as a binder. For a sleeve injection in a horizontal cable, the split lead sleeve with a flange attached can then be placed, with the flange on the top. The sleeve seam is soldered shut and the sleeve is joined to the sheath at both ends as stated in paragraph 6.052. The sealing compound then can be injected through the flange by pressure gun. The quantities of compound required are the same as given in Table 3.

6.054 The procedure for plastic-sheath cable having an inner plastic extrusion under the shield is similar to that stated in the preceding paragraph. Exceptions are that the sheath opening is made about 11 inches long, that the inner plastic extrusion is left projecting one inch into the opening at each end and that dry 1/2 inch cotton tape is lashed over the core at the ends of the remaining 8 inch opening which exposes the core wrapping. From this point on the procedure is the same as given in paragraph 6.053 for cable without the inner plastic extrusion. The sealing compound is injected by pressure gun.

6.06 Sleeve Injection - Plastic-Sheath, Polyethylene-Insulated Cable

6.061 The plugs in plastic-sheath, polyethylene-insulated cable should be made in the straight sections to avoid bending strains. They can be in a vertical as well as a horizontal section of cable. Their location with respect to splices is the same as stated in paragraph 6.031. Where paper-insulated cable is spliced to polyethylene-insulated cable, a plug should be placed in the polyethylene-insulated cable near the splice to prevent moisture travel from the polyethylene cable into the paper cable. This is not necessary if the two kinds of cable are both pressurized. The method of making a plug described herein is for cable having a longitudinal shield. Cable having a spiral shield will differ in requiring the placing of a metallic bond across the opening soldered to the shield to give electrical continuity to the shield. (See Figure 5)

6.062 A sleeve plug in a horizontal cable is made by removing 4 inches of sheath on cables 1-1/4 inch diameter or less and 7 inches on larger cables; cutting off some of the shield but leaving a strip intact for electrical connection; ballooning the conductors; building up collars over the sheath with pressure-sensitive tape; applying a sheet of heavy wrapping paper around the opening extending onto the tape collars, with a slit lengthwize along its top; applying wire cloth around the sheath adjacent to the tape collars; applying a split lead sheath over the paper cylinder and tape collars, aligning its split with the slit in the wrapping paper cover; beating in the ends of the sleeve to engage the wire cloth and soldering it thereto; wrapping pressure-sensitive tape over the ends of the sleeve and out along the sheath for a short distance; spreading the slit in the lead sleeve to about a 1/2 inch gap; filling the sleeve through the aligned slits with sealing compound; waiting about 15 minutes and then pouring in additional compound if noticeable setting has occurred; beating the sleeve slit closed to a narrow gap without soldering it closed; and finally wrapping the entire structure with pressure-sensitive tape half-lapped to about 1-1/2 inches beyond the previous wrapping. The above method follows closely the procedure specified in paragraph 6.052 as to joining the sleeve to the sheath.



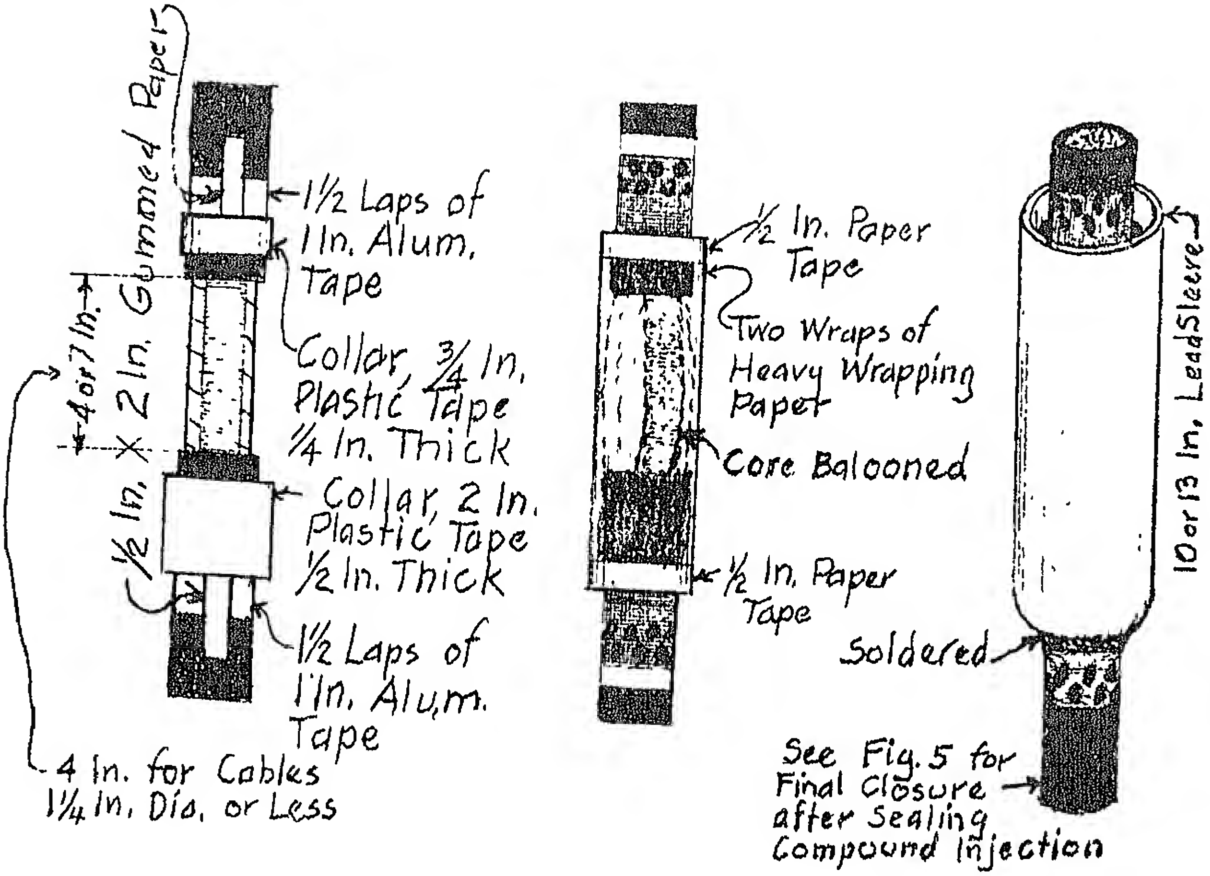
Sleeve Injection - Plastic-Sheath, Plastic-Insulated Cable

Figure 5

6.07 Sleeve injections in vertical runs of lead-sheath cable and plastic-sheath, paper-insulated cable can be made using the split lead sleeve method with flanges for injecting the sealing compound. (See Figure 6) The quantities of sealing compound required are given in Table 3. Sleeve injections in vertical plastic-sheath, polyethylene-insulated cable are made in a manner similar to the method described in paragraph 6.062 as to the use of split sleeve, tape collars,method of joining the lead sleeve to the sheath and final tape covering. One major difference is that the upper of the two tape collars is made smaller in diameter than the lower one. The lower end of the lead sleeve is joined to the plastic sheath in the usual manner using a ten inch sleeve for a four inch sheath opening and a 13 inch sleeve for a 7 inch opening. It is not considered necessary to close the slit in the sleeve by soldering it. The sealing compound is poured into the top of the sleeve up to the top of the upper tape collar, allowing about 15 minutes for it to settle and pouring in more compound if needed. The upper end of the sleeve is then joined to the sheath in the usual manner. The entire sleeve is then covered with two inch pressure-sensitive tape half-lapped and finally with vinyl one inch tape half-lapped.

6.08 The quantities of sealing compound required for sleeve injection in plastic-sheath, polyethylene-insulated cable are as given in Table 3. The D Sealing Compound used for plugs in polyethylene-insulated cable must have the Glass Mill End Fibers added during the mixing operation.

6.09 The D Sealing Compound is toxic to some people. All workmen who have occasion to use it or clean the tools and the C Pressure Gun after using it to inject compound should protect their hands by applying Kerodex Creams to them before using the compound. Water repellent Kerodex 71 is applied first followed by Kerodex 51 which washes off easily. The Kerodex 71 is applied to clean dry hands and wrists. About 1/2 teaspoonful of Kerodex 71 is placed in a palm and then spread evenly over the hands, wrists, and between the fingers, rubbing it in thoroughly for about one-half minute or more. The excess should be wiped off with a clean dry cloth. After waiting a few minutes about 1/2 teaspoon of Kerodex 51 is placed in a palm and similarly applied over the layer of Kerodex 71. The excess should be wiped off with a clean dry cloth after the cream has been allowed to set. Care should be taken not to touch the hands to the face or other parts of the body until the Kerodex 51 (which may be contaminated) has been washed off the hands upon completion of plugging work. If the sealing compound is being used throughout the day the creams should be reapplied two or three times a day. It also is advisable to wear goggles when using the sealing compound.



Sleeve Injection - Vertical Plastic-Sheath, Plastic-Insulated Cable

Figure 6

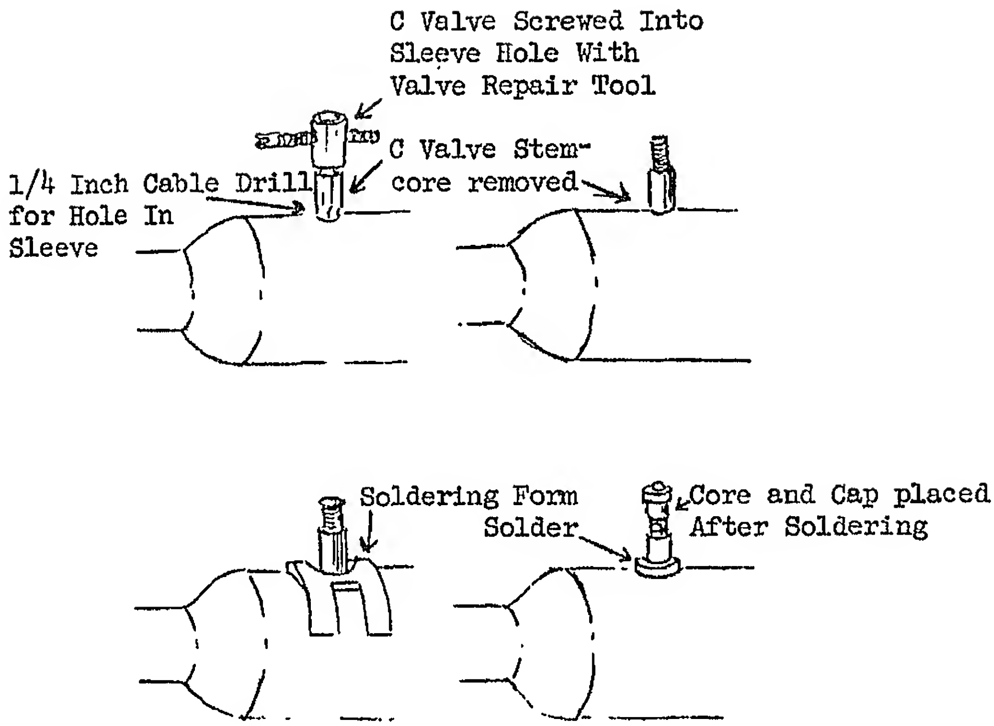
6.10 The C Pressure Gun should be cleaned upon the completion of each plug because the compound hardens rapidly. The cap and piston are removed and the piston and its leather washer are wiped thoroughly with a dry cloth. The round end of the B Cleaning Rod is run through the nozzle orifice and the rod is then wiped clean. The interior of the gun barrel is wiped with a cloth moistened with KS-16302 Cleaner and dried with a cloth. Tools of other kinds that have been in contact with the sealing compound should be cleaned similarly. If the compound has become badly caked in the gun or on other tools they should be soaked in the cleaner long enough to permit loosening of the compound to permit its removal. After such cleaning the parts should be wiped clean with a dry cloth.

7. PRESSURE TESTING VALVE INSTALLATION

7.01 The C Pressure Testing Valve can be installed on horizontal lead sheath at any point along the sheath or on any lead sleeve that has not been filled with paraffin or any other sealing compound. The preferable location is on a sleeve 3 or 4 inches from the wiped joint and at the end of the sleeve toward the pole if the sleeve is adjacent to a pole. A hole is bored through the lead sheath or sleeve with the 1/4 inch cable drill. The valve core is removed and the valve is screwed into this hole using the Valve Repair Tool as a wrench. A soldering form is placed over the valve stem and the stem then is soldered to the cable or sheath. The form is removed and the valve core is inserted and a valve cap placed on the stem. (See Figure 7)

7.02 The F Pressure Testing Valve can be placed readily on a metal splice case if this has a "terminal flange" into which the 1/8 inch pipe threads of this valve can be screwed. The flange is a hole bored and tapped in the splice case in which a metal plug is screwed at the factor. The threads of this valve also fit the inside threads of the D Pressure Flange. This flange can be placed on the lead sheath or sleeves of large diameter cable by first boring a hole using the 3/8 Inch Cable Drill, screwing the flange into this hole and then soldering the flange to the lead sheath or sleeve.

7.03 The F Pressure Testing Valve can be installed on the sheath of plastic sheath cable where no splice case is located at the desired test point. The method for installation will depend on the cable diameter and whether the cable is aerial, in underground duct or buried. A ten inch splice case (13A) made for plastic sheath cable up to 1.0 inch diameter is available for this use. A ten inch splice case (14A) for plastic sheath cable 1.0 inch to 1.6 inch diameter also is available. These splice cases, which are die-cast aluminum, have a hole bored and tapped



Installation of C Pressure Testing Valve in Lead Cable

Figure 7

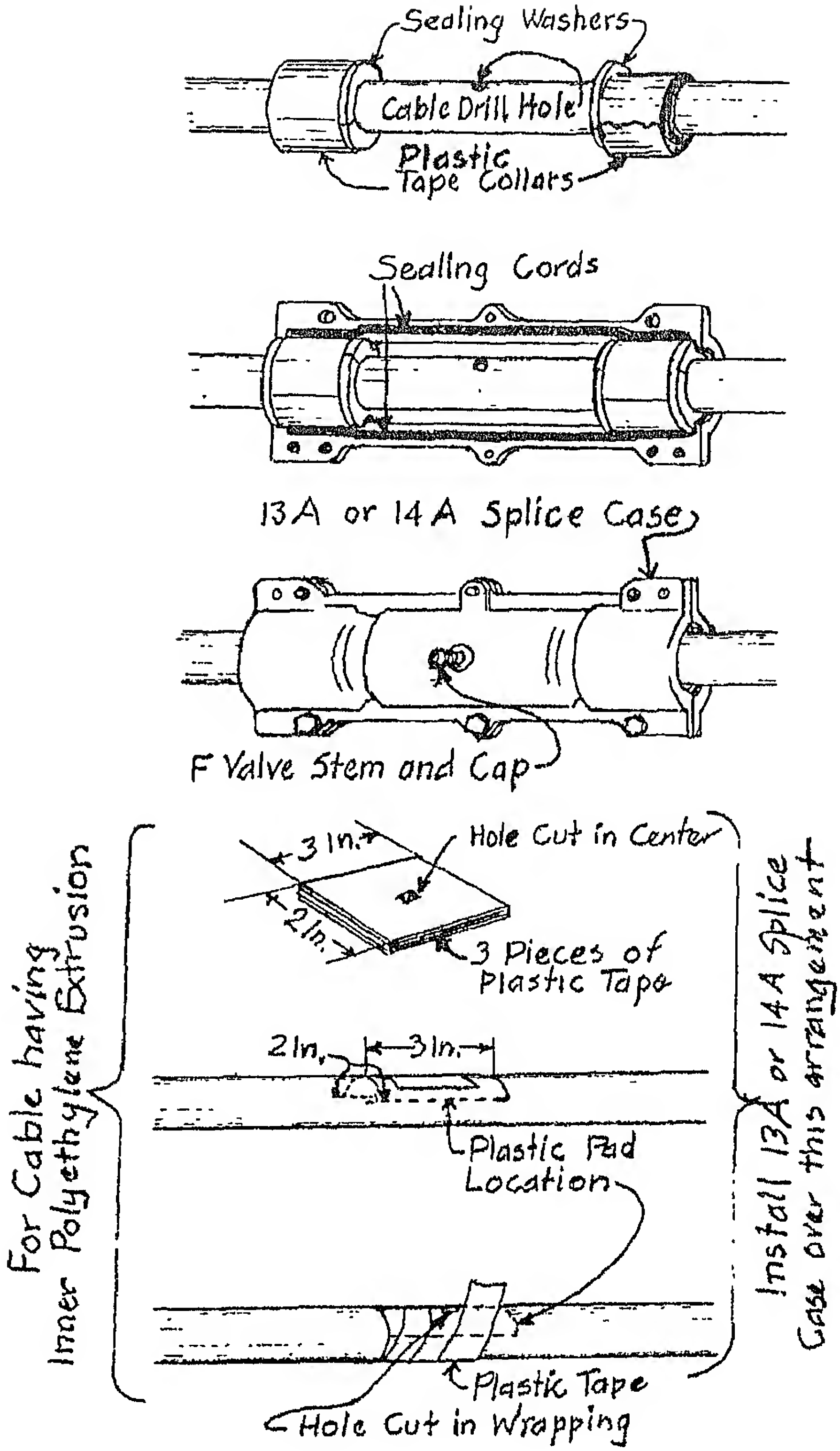
in the side with threads which fit the F Valve. One of the purposes in the design of these short splice cases is to permit pressure testing valve installation in aerial plastic sheath cable. These splice cases can be used on Alpeth, Stalpeth and PIC cables. This installation requires a minimum of work to make a small sheath opening to be covered by the case.

7.04 For plastic sheath cable having no inner extrusion of plastic a hole is bored through the sheath and metal shield with the 1/4 Inch Cable Drill being careful not to cut into the cable core. Two collars of suitable diameter are wrapped on the cable sheath with the sheath hole between them. The splice case is used as a gauge to locate the collars. The sealing cord is placed in the back splice case and the front case is then applied and bolted to the back case. The F Pressure Valve then can be inserted in one side of the splice case in the opening provided. (See Figure 8)

7.05 If the cable has an inner extrusion of plastic under the metal shield, the procedure begins by cutting an opening in the sheath and shield about two inches long and extending 1/3 of the cable circumference. A hole is then bored through the inner extrusion using the 1/4 Inch Cable Drill. A pad made of plastic tape three layers thick large enough to cover the two inch opening is placed over the opening. It is taped over the opening and a hole cut through it at its midpoint. The splice case can then be installed as mentioned in the preceding paragraph.

7.06 For plastic sheath cable larger than 1.6 inch diameter, the use of a split lead sleeve is suggested to which a C Pressure Flange can be soldered. This flange has inside threads which fit the threads of the F Valve. The split sleeve method also is suggested for installing the F Valve on underground or buried plastic sheath cable. The lead sleeve is joined to the plastic sheath using the method described in paragraph 6.052 under "Cable Plugging Procedure." The C Pressure Flange is installed in the split lead sleeve for mounting the F Valve.

7.07 The B Pressure Ell can be inserted in splice case flanges and in any D Pressure Flange by reason of thread conformity. The ell is brass and has one end in tubular form over which 1/2 inch OD lead pipe can be slipped on and soldered thereto for such purposes as connecting to 1/4 inch OD tubing at a by-pass valve. A tapped hole is on the opposite side of the ell from the tubular end, with threads to take an F Pressure Testing Valve.



Installation of F Pressure Testing Valve on Plastic-Jacketed Cable

Figure 8

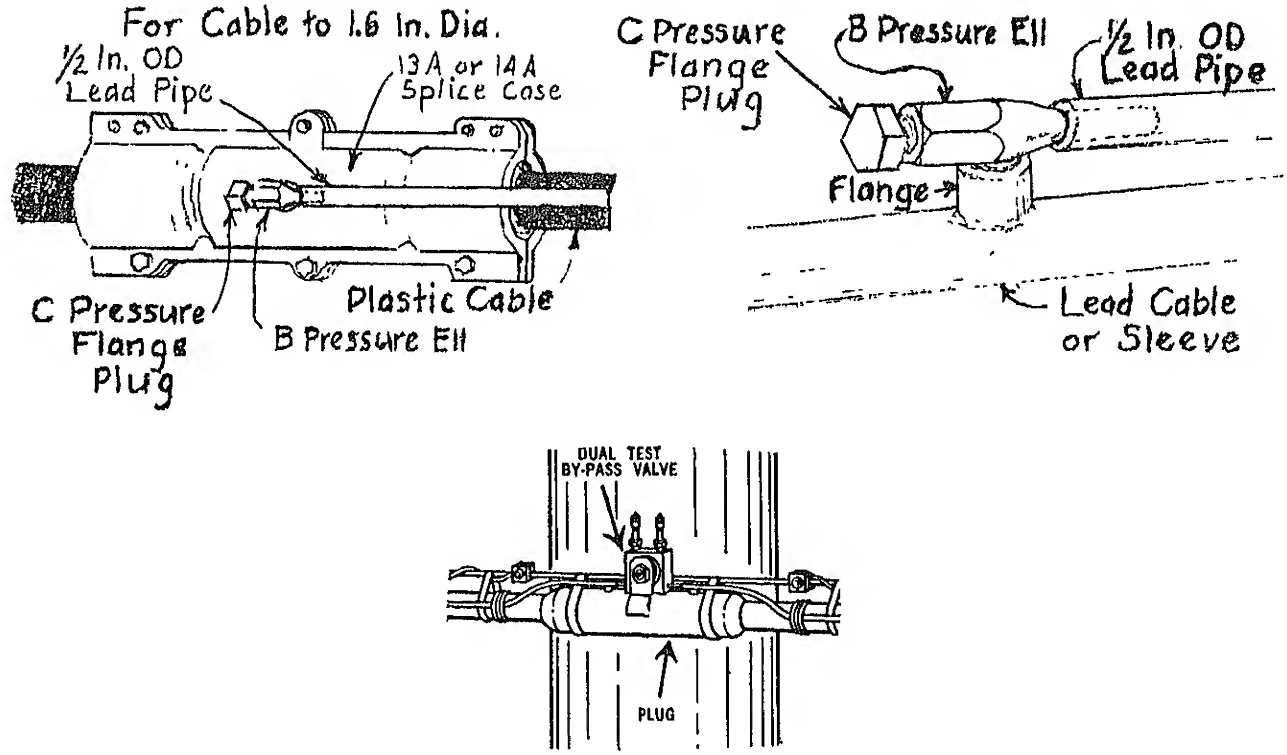
8. BY-PASS CONNECTIONS

8.01 As mentioned in paragraph 3.04, cable should be sectionalized by installation of plugs which shut off air flow at points along a pressurized cable. These must be by-passed by lead pipe which connects the by-pass valve to the cable in both directions. As stated in paragraph 4.04 three types of by-pass valves are available. The by-pass valves have mounting plates which permit attachment to poles, walls and cable sheath or sleeve. They can be lashed to a lead sleeve with three or four turns of lead lashing wire. (See Figure 9)

8.02 For a by-pass valve installation on a lead sheath cable two flanges are placed on the sheath one each way about four feet from the plug. B Pressure Ells are screwed into these flanges and 1/2 inch OD lead pipe is placed between B Ells and the by-pass valve. This valve is placed near the center of the plug location. The lead pipes are soldered to the tinned pipes of the by-pass valves and the lead pipes are then lashed to the cable with lead lashing wire. The four foot distance from the plug to the flanges insures that the by-pass connections are beyond the resin compound in the plug. Each B Ell has a C Pressure Flange Plug screwed into one end. A torch can be used for the soldering work on aerial cable. A soldering copper should be used for the soldering on underground cable.

8.03 For a by-pass valve installation on plastic sheath cable the 13A or 14A Splice Cases should be used if the outside diameter of the cable does not exceed 1.6 inch. One of the cases is placed each way about four feet from the plug. B Pressure Ells are inserted in the flanges in the cases as shown in Figure 9. The by-pass valve is connected to the B Ells with 1/2 inch OD lead pipe which is soldered to the B Ells and to the by-pass valve pipes with a blow torch. The by-pass valve and the lead pipes should be lashed to the cable and strand with lead lashing wire.

8.04 For plastic sheath cables of more than 1.6 inch diameter the split lead sleeve method of providing for a flange should be used. Diameters of cables are listed in REA TE & CM-630, "Design of Aerial Cable Plant." The manner of placing such a sleeve on a plastic sheath is described in paragraph 6.052. An opening is cut through the sheath, shield and core wrapper using a cable drill. This will give air access to the sleeve from the cable. The C Flange is soldered to the lead sleeve over a hole bored through it with a cable drill. A by-pass valve at a plug requires such a sleeve placed about four feet from the plug in each direction. The B Ells are placed in the sleeve



By-Pass Valve
and
Connections to Cable

Figure 9

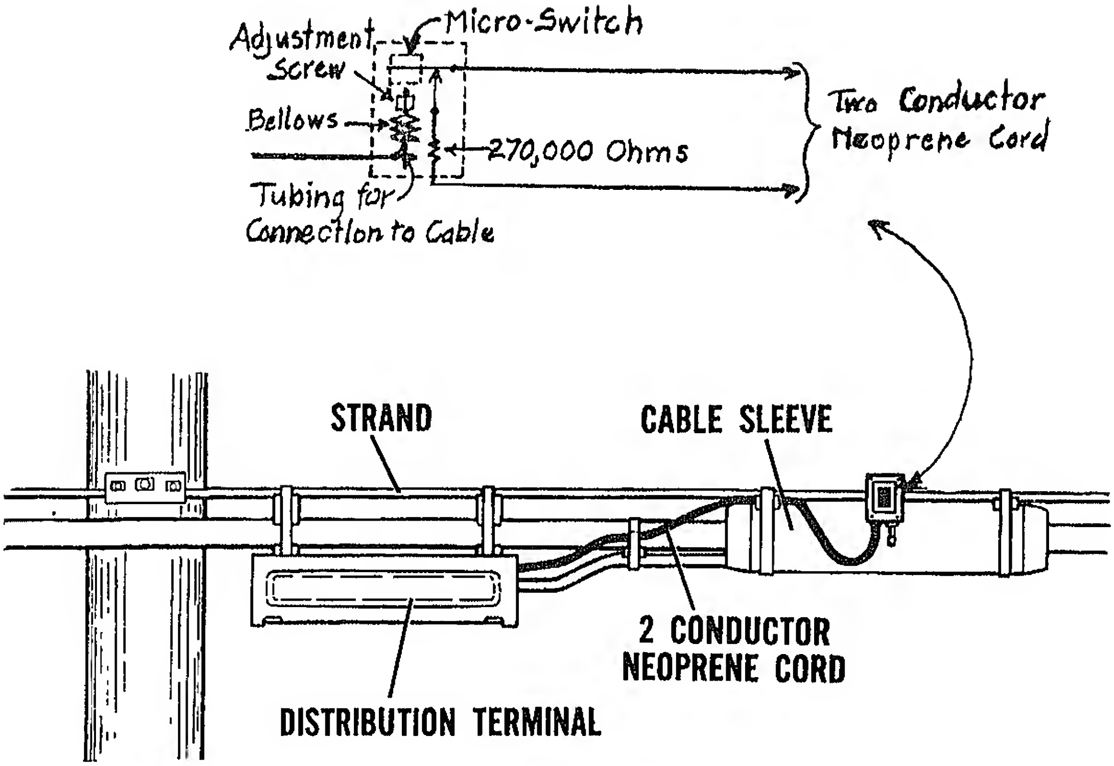
flanges and 1/2 inch OD lead pipe is placed to connect each B Ell to the by-pass valve and soldered thereto. The lead pipes and by-pass valve are lashed to the cable and strand with lead lashing wire.

8.05 As mentioned in paragraph 3.17 filled sleeves or other known restrictions which block the flow of air in a pressurized cable must be by-passed but ordinarily without a by-pass valve or pressure testing valves. For this purpose Pressure Testing Ells can be soldered to lead sheath on each side of the restriction and connected together by 1/2 inch OD lead pipe soldered thereto. For plastic sheath cable the split lead sleeve method or the splice case method can be used for making the connections to the cable.

9. PRESSURE CONTACTOR INSTALLATION AND ADJUSTMENT

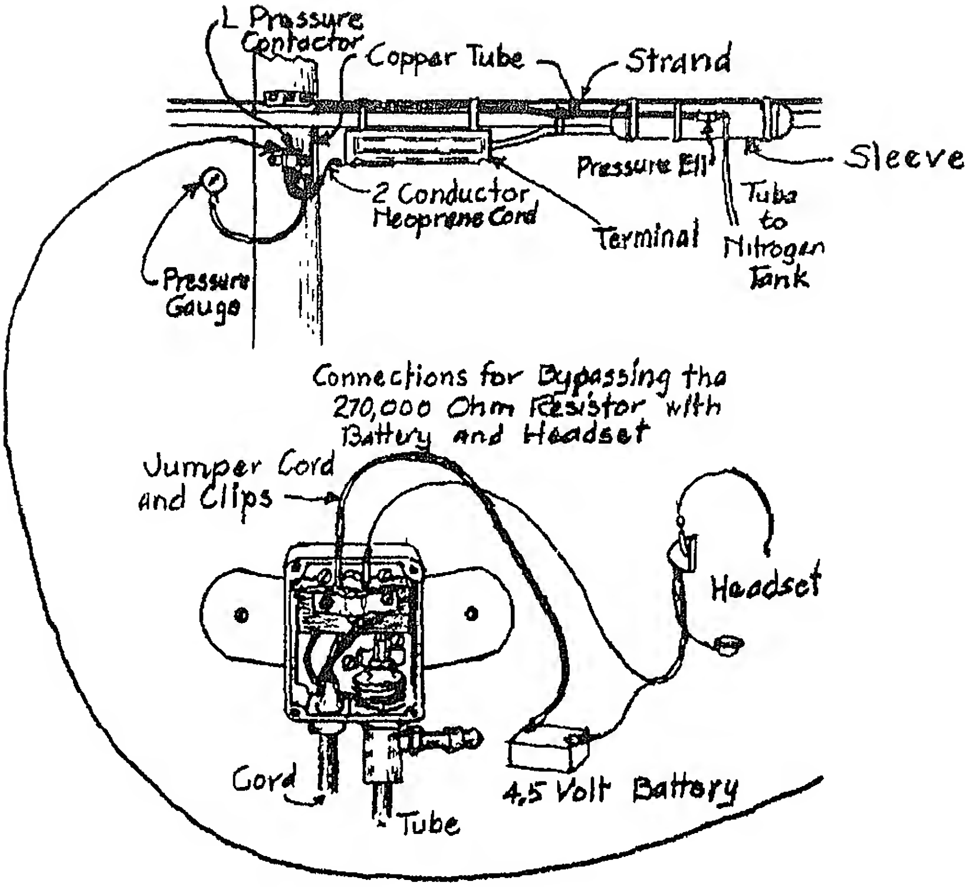
9.01 The pressure contactors mentioned in paragraph 3.02 are available in two types. The L Pressure Contactor is intended for mounting on a pole or wall for which use it has a mounting bracket attached. This contactor is provided with six feet of 1/4 inch copper tubing to connect it to the pressurized cable. It is installed near a cable terminal into which a connection is made with two conductor neoprene cord to an assigned working line cable pair. The M Pressure Contactor is similar to the L type but is intended to be attached by a pipe threaded fitting on its back which permits making a direct air connection to a splice case, a flange on a cable sheath or a sleeve. A 1/8 inch Chromium-plated Street Ell is provided with it for mounting it on a splice case of the type which has its flange on top. Connection is made with two conductor neoprene cord to an assigned cable pair in a terminal. Six feet of the neoprene cord is supplied with both L and M contactors. (See Figure 10)

9.02 An L or M Pressure Contactor can be connected to an exchange aerial cable at any terminal location where the pressure measured is 1.5 psi or more. The M type is the easier of the two to install. Both can be adjusted for any pressure between 1 and 10 psi. The method of adjustment is the same for both types. The adjustment is made after the contactor has been mounted on the pole, wall, splice case or sleeve in its permanent location. A head-set, C Pressure Gauge, 4.5 volt battery, a 1/4 inch open end wrench, a screwdriver and an O. P. nitrogen gas cylinder are required in making an adjustment. The first requirement is that the normal pressure at the contactor location be determined as described in paragraph 3.12. The usual practice is to adjust the contactor to operate at 0.5 psi below the normal pressure at the location. (See Figure 11)



Pressure Contactor Circuit and Connections

Figure 10



Pressure Contactor Installation and Adjustment

Figure 11

9.03 The head-set is connected by clip-ended cords to the two terminals at the top of the contactor. This by-passes the 270,000 ohm resistance. A click will be heard in the receiver when the contacts close due to reduction of pressure in the bellows of the contactor. A pressure testing valve for temporary use must be placed through which gas from the O. P. nitrogen gas cylinder can be injected into the cable through a hose and chuck. This is the "control" valve. The C Pressure Gauge is connected to the pressure testing valve on the bottom of the contactor. Pressure in the cable is built up to a value higher than the "normal," from the nitrogen gas cylinder. The nitrogen gas cylinder hose chuck is then removed from the control valve. The cap of the control valve then is used to bleed the pressure

through this valve until the click indicating contactor operation is heard. The pressure at this instant is noted on the C Pressure Gauge. The operating psi value of the contactor is changed by turning the contactor adjusting screw clockwise to increase the value and counterclockwise to reduce it. After the bleeding, the pressure will rise as the internal pressure adjusts along the cable. It will be necessary to again apply nitrogen gas for a second test. At least two tests should be made before the adjustment is considered satisfactory. The two conductor neoprene cord then can be connected to the working line cable pair assigned for use. The contactors, when received, usually are adjusted at about 2 psi. After they operate they require a rise of about 0.25 psi above their "operate" value to cause the contact to reopen.

10. SEALING OF THREADED CONNECTIONS

10.01 The installation of pressure valves, pressure contactors and ell fittings involve threaded connections which should be made airtight by applying pipe joint compound to the threads when making connections. This material is available in cans at hardware stores and in stick form such as "Pipetite-Stick" or equivalent.

11. EXCHANGE CABLE PRESSURIZATION SYSTEM DESIGN

11.01 When designing an aerial cable system for a new project if polyethylene-insulated cable is to be used, a choice between three policies should be made. These are: (1) use of ready-access enclosures without cable pressurization; (2) use of airtight splice cases and terminals with pressurization; and (3) use of ready-access enclosures, with plugs and by-passes, with pressurization. The decision usually will be in favor of choice (1) because of the lower cost and the advantages derived by the use of ready-access enclosures, and due to the fact that polyethylene-insulated cable gives little trouble and low maintenance cost. In any case the miles of sheath and its maintenance costs involved must be sufficient to justify the expense of pressurization.

11.02 An exchange cable pressurization system usually has the dry air pressurization equipment installed in a central office where the air supply is connected to the outgoing exchange cables. Decision has to be made as to the locations for the contactors where they will perform the greatest service in cable protection against out-of-service conditions. If there is a feeder cable extending 1,000 feet or more along any route from the office, either aerial, in underground duct or buried, a logical place for a contactor is at the junction of the feeder and the aerial distribution cable. For other contactor

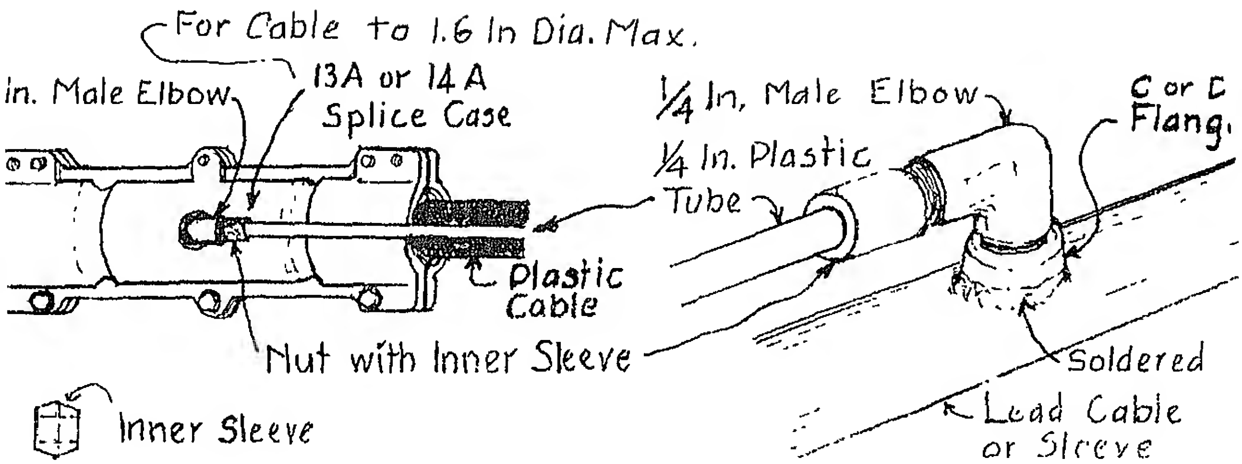
locations it is desirable to wait long enough after pressurization for the pressure to stabilize along the cables after the initial cleanup of leaks has been completed. Then pressure tests can be made and contactors located where at least 1.5 psi is found. This will result in a maximum amount of protection.

11.03 Contactors should be located where they will monitor as much of the connecting branch cables as practicable. They should be installed at the ends of cables to military establishments, airports and other important establishments. The contactor at the junction of the feeder and distribution cables will monitor the cable back to the central office as well as outward to a definite range of 20 as stated in paragraph 3.11. Addendum B gives examples of cable networks that are typical of contactor locations which will give satisfactory protection. The layouts are based on data from Table 1 in paragraph 3.09.

11.04 The locations of pressure testing valves, by-passes, plugs and alarm contactors should be carefully shown and maintained on the maps of the cable system. Suggested symbols for such record work are shown on Addendum C.

2. PRESSURIZATION CONSTRUCTION PROCEDURE

12.01 The first operation in preparing a cable for pressurization is to install a plug in it in the central office to prevent loss of air through the tip cable. The air supply from the air flow meter panel for each cable then should be connected to the cable on the street side of the plug with 1/4 inch OD of plastic tubing. This tubing can be the Dekoron tubing or equivalent. It is available as single or multiple tubing, clear or color coded. If the cable has lead sheath, a C or D Pressure Flange should be soldered to the sheath and used to guide the cable drill to bore through the sheath. A male elbow fitting is attached to the flange for connecting the plastic tubing to the cable. If the cable exceeds 1.6 inch diameter a split lead sleeve will be necessary for mounting a flange, as described in paragraph 7.06. If the cable has a plastic sheath not over 1.6 inch diameter the air connection to the cable can be made by using a 13A or 14A Splice Case described in paragraph 7.04 with a male elbow fitting for attaching the tubing to the splice case. The compressor-dryer should be connected to the air flow meter panel by 3/8 inch OD plastic tubing. (See Figure 12)



Plastic Tubing Attachment to Cable in C. O.

Figure 12

12.02 Air pressure should be applied to not more than two cables at one time to prevent overload of a small 250 cubic foot per day compressor unit. Overload may occur if one of the cables has a large leak. If an airflow meter shows excessive airflow to a cable it is advisable to proceed immediately to find the leak. This is done in the following manner: The by-pass valve is closed at the far end of the first mile of cable. After a few hours' time in which the pressure should stabilize in this mile pressure, readings should be taken in that mile. If stabilization occurs this fact eliminates this mile and the by-pass valve should be opened and the next mile tested. When a leaky mile is found proceed as stated in paragraph beginning at paragraph 12.08.

12.03 The cables that do not show excessive leaks should be tested in the following manner. A 224 cubic foot O. P. nitrogen gas cylinder should be connected one-half mile from the central office on one of the cables and the by-pass valve should be closed at the one mile point. The injection pressure should be set for 6 psi. A pressure regulator is required to reduce the approximately 2265 psi of the nitrogen gas cylinder to the 6 psi for injection into the cable. Some nitrogen suppliers have the regulators available on a rental basis. A 224 cubic foot cylinder of O. P. nitrogen gas costs in the order of $50 with the free use of the cylinder for 30 days and a small fee per day for more extended use.

12.04 It may take a day or two for the pressure in this mile of cable to stabilize, at which time the regulator will show no flow of gas into the cable if the cable has no large leak. If the cable pressure stabilizes, indicating no leaks, the cylinder of gas can be moved to the next adjacent mile midpoint and the by-pass valve opened between the two miles of cable. The by-pass valve at the distant end of the second mile of cable is closed during the gas injection into it. These operations are repeated mile by mile until the entire cable has been tested. This testing should be performed on all of the cables that are pressurized.

12.05 The objective is to obtain as near 2 psi as possible at the ends of all main distribution and branch cables. They may not be possible in small size branch cables due to their length and high pneumatic resistance. The work involved in repairing minor leaks and terminal stub plugging in the branch cables may not increase the pressure enough at their ends to be justified. End point contactors should not be installed beyond the point where the pressure from the central office falls below 1.5 psi after the initial trouble clearing is finished. Temporary pressure testing valves may be required to locate places where air passage is blocked.

12.06 To protect an underground cable in a manhole containing water above the cable it is necessary to have a minimum pressure in the cable calculated as follows:

$$\text{psi (minimum desirable)} = \frac{\text{waterhead (feet)}}{2} + 1$$

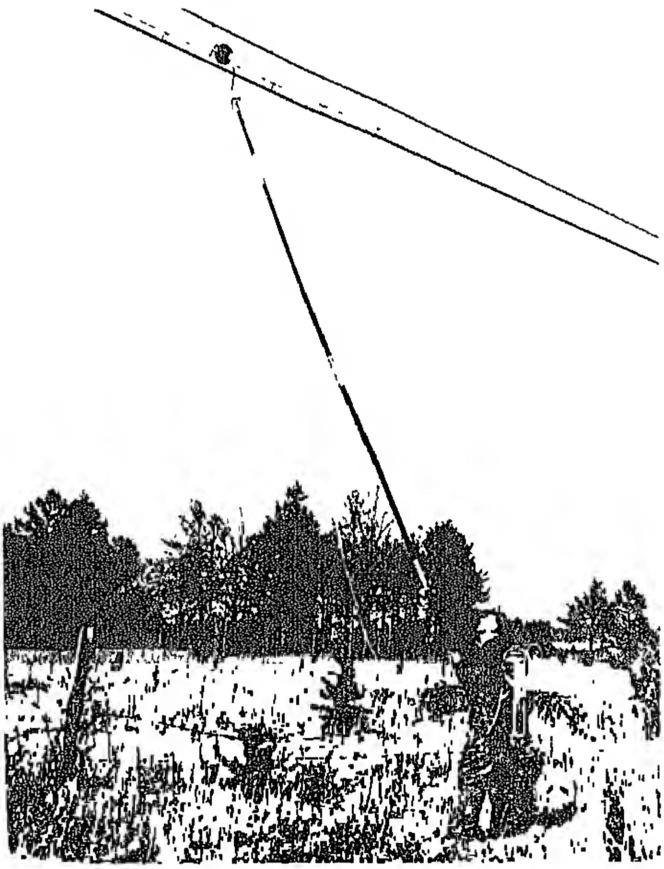
However, a cable pressure of 1 psi will protect against a waterhead of about two feet.

12.07 Experience in this initial cleanup work has shown that a 224 cubic foot cylinder of nitrogen gas may be exhausted in half a day if the lead aerial cable is old, badly cracked, ring cut and with numerous leaks. If the lead cable is under ten years old and in good condition, one of these large cylinders of gas may be sufficient to supply cables for four or five working days and permit testing several miles of cable. The amount of gas required per mile depends on the size of the cable as well as its condition. A cable one inch in diameter, 1,000 feet long, takes about 0.2 cubic feet of gas to raise the pressure 1.0 psi. This is approximately a 101 pair, 22 gauge paper cable. A 2.0 inch cable takes four times this much gas.

12.08 If a mile section of cable fails to stabilize from the nitrogen injection after two days, it is evidence that there are serious leaks that must be found and repaired. A chart made from the pressure readings taken at the pressure testing valves in the mile section of cable will give data for making a gradient chart which should show the approximate leak location. Evidence such as a recent pole move or replacement or other work on the cable can be looked for in the neighborhood of the place indicated by the pressure gradient. Paragraph 13 gives the steps required in making a pressure gradient chart.

12.09 Failure to promptly find the leak by visual inspection of the general location indicated by a pressure gradient chart will require spray testing of the suspected section of aerial cable, perhaps for a few spans. The one-wheel roll sprayer on a pruner pole, connected to the 4-1/2 gallon spray tank can be used. This sprayer can be used on either lashed cable or cable in rings. A slightly different adjustment of the nozzles is required for the two types of cable suspension. These items are listed in paragraph 5 and can be purchased as a "kit" for less than $200. The 4-1/2 gallon tank can be carried on the tester's back or on a tank carrier. The tank carrier with a 25 cubic foot nitrogen cylinder to supply pressure to the tank is inconvenient on rough terrain. The 25 cubic foot cylinder can be charged from a 224 cubic foot cylinder using the Cylinder Charging Connector. The roll sprayer kit in use is shown in Figure 13. The tests usually are accomplished by a two man team, one man to operate the sprayer and the other to watch for spray bubbles. However, one man can make the tests if the working conditions are safe. The sprayer can be pushed along with the pole at a 45 degree angle. For high cable it can be pulled along with a light handline. It should be moved slowly enough to permit the spray to thoroughly wet the cable. A small leak may be overlooked if passed over too rapidly. The 4-1/2 gallon tank has a pressure gauge and safety blowout plug which will release if the tank pressure exceeds about 40 psi. The normal pressure for spraying should not exceed 30 psi nor fall below 20 psi. The spraying should be done while the 224 cubic foot nitrogen gas cylinder maintains pressure on the cable not in excess of about 5 or 6 psi.

12.10 The kit includes the one-wheel roll sprayer with pressure tank and plastic tube for connecting the tank to the sprayer, Fiberglas sectional pruner pole, flash leak tester, 24 plastic bottles of C Concentrate sufficient to make 72 gallons of test solution, 6 air valves for attachment to cable in applying nitrogen gas for test pressure, 25 feet of plastic tube equipped with fittings on one end for attachment to air valves on cable



Spray Leak Locating

Figure 13

and at the other end for attachment to a cylinder of nitrogen gas and a cable drill for piercing cable sheath after a valve is placed.

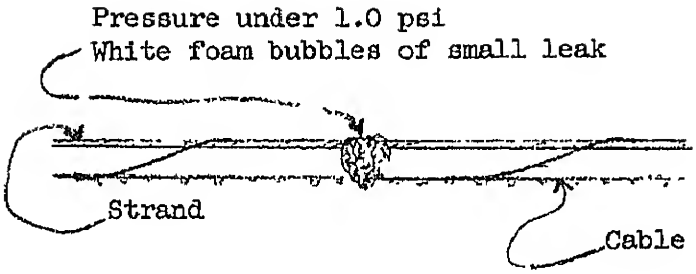
12.11 Figure 14 shows the types of bubbles that can be expected at leaks of various sizes. Windy weather blows the bubbles away and it is not a desirable time for spray testing. Also, wind tends to make bubbles at non-leaks particularly on lashed cable. Pressure greater than 5 or 6 psi in the cable does not make good bubbles except in hot weather when cracks tend to become smaller. A large hole in a sheath such as by a bullet may not make a bubble nor a noise from leaking air or gas. If the spray test does not show bubbles at or near where the pressure gradient indicated, it may be necessary to ride the strand in a cable car or inspect carefully by ladder using a flash leak tester. The tank is 4-1/2 gallon capacity but should not be filled over 3-1/2 gallons to leave room for pressurizing. Otherwise it would have to be pumped up too often to maintain 30 psi in the tank if not used with the nitrogen cylinder. A tank with 3-1/2 gallons of solution should spray about 800 to 1,000 feet of cable. The time required to spray is 3 to 5 minutes per span and 2 or 3 miles of sheath can be covered in one work day. Resulting bubbles will be below usual size on cables paralleling a diesel railroad as a greasy residue of oil combustion prevents spray adhesion to the sheath. Water for refilling the tank can be carried on a drum on the truck or obtained locally along the cable route.

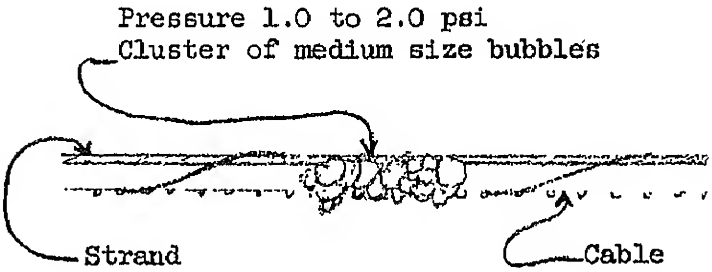
12.12 Underground cable can be tested in the manholes by means of the flash leak tester, a hand sprayer, with a brush and bucket of water-concentrate, or by listening for the sound of escaping air or gas.

12.13 Paint or dye can be used to mark leaks when detected but these leaks generally should be repaired before the end of the work day they are detected. This avoids waste of the nitrogen gas and builds up the pressure faster toward stabilization.

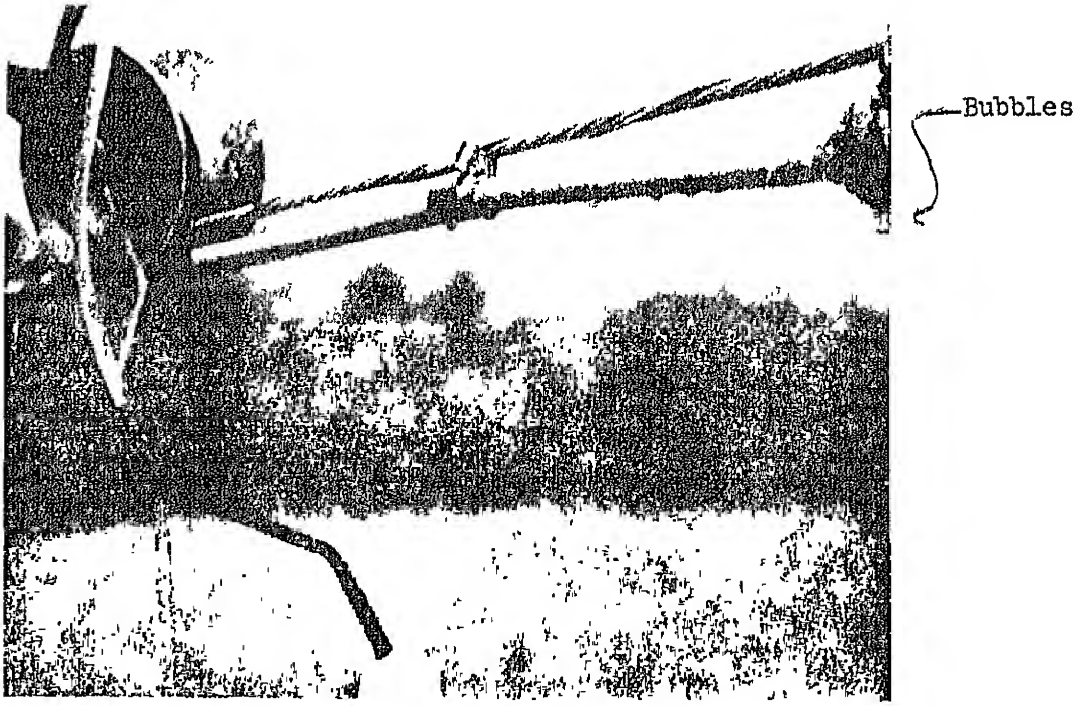
12.14 The same procedure for spray testing with the roll sprayer is used on both plastic and lead sheath cables. The water-concentrate solutions for the two are different as described below.

12.15 Only the B Pressure Testing Concentrate should be used for spraying polyethylene sheath cable although it can also be used on lead cable. It is available in 4 ounce and 1 gallon





Note: Large leaks may not bubble but may give momentary indication



Typical Water-Concentrate Bubbles

Figure 14

containers. In weather above freezing the spray solution should be one part concentrate to ten parts clean water.* In freezing weather more concentrate is required, one part concentrate to 2 parts water at 20° down to 5°F. This solution should be used for brush and bucket testing, also with the flash leak tester. This concentrate is more expensive than the C and D concentrates.

12.16 Only the C Pressure Testing Concentrate should be used for spraying on lead sheath cable at temperatures above 32°F. It damages polyethylene sheath and must not be used on such cables. It is available in 4 ounce plastic bottles. The solution should be one 4-ounce bottle of concentrate to three gallons of clean water.*

12.17 Only the D Pressure Testing Concentrate should be used for spraying on lead sheath cable when the temperature is 5° to 32°F. It also damages polyethylene sheath. At 5° to 15°F. the solution should be one part concentrate to two parts clean water. From 15° to 32°F. it can be one part concentrate to 5 parts clean water.*

12.18 The roll sprayer can be used with all three solutions. After a roll sprayer has been used in locating leaks, the tank, plastic tubing and sprayer should be rinsed out with clean water at the end of the day's work. All foam and solution should be removed from the tank. A gallon of water then should be put in the tank and the pressure raised to about 20 psi. The trigger valve then should be operated and the water allowed to flow through the tube and sprayer until all solution and foam are removed. The tank then should be emptied and pumped up to about 20 psi and all water blown from tubing and sprayer. The strainers in the spray nozzles and the trigger valve should be cleaned by rinsing in clear water after about 40 hours' use or after being idle some days. The hand pump leather washers should be oiled periodically.

13. PRESSURE GRADIENT CHART PREPARATION

13.01 The steps that are required in preparing a pressure gradient following the discovery that a leak exists include (1) [pre]liminary leak locating and (2) final leak locating.

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*[Wat]er is satisfactory if it is relatively free of sulphur concentrate should be added to the water and stirred well.

13.02 The preliminary leak locating is done by taking the pressure readings at pressure test valves using the C Pressure Testing Gauge. Readings are taken at all of the valves in the mile section of cable. Tests for leaks at the valves should be made before and after the valve caps are removed using a brush and bucket of water-concentrate solution. The readings should all be made by one man using one pressure gauge. Temperature affects pressure readings. The best time to take such readings is during a steady rain. Sunlight on part of the cable section and shade on part may distort the readings. Pressure readings on underground or buried cable will not be affected by temperatures. In any case all of the readings should be made in the shortest practicable time.

13.03 The final leak locating suggested is by the "two-direction" method of taking pressure readings. The tester should begin at the pressure source end of the leaking section of cable, reading and recording the time and the pressure, proceed to the next valve toward the trouble, recording the time and pressure there; repeating this until he has also recorded the data for all of the valves in the mile of cable. He should immediately retrace his steps and record the readings of the valves and the time of each reading in reverse order. The elapsed time between readings at any two adjacent valves should be approximately the same for both directions of travel. The readings then should be tabulated and the average of the two readings at each valve can be added to the tabulation. Such a tabulation is given below:

TYPICAL TWO-DIRECTION DATA

Pressure Valve Location	Interval Between Readings	First Readings		Second Readings		Average Pressures to be Plotted
		Time	Pressure	Time	Pressure	
No. 39	10 min.	2:00 PM	4.66 Lbs.	3:40 PM	4.60 Lbs.	4.63 Lbs.
40	15 min.	2:10	4.63	3:30	4.59	4.61
41	10 min.	2:25	4.54	3:15	4.50	4.52
42	5 min.	2:35	4.53	3:05	4.51	4.52
43	10 min.	2:40	4.57	3:00	4.55	4.56
44		2:50	4.62	-	-	4.62

13.04 Where a cable route is in terrain that is not level, the pressures will tend to be greater at valves in low places then they would be in level terrain. Where the level differences at valves are great, it may be necessary to convert pressure readings to their equivalent values at a common elevation. However, this correction should not be necessary except perhaps in underground or buried cable where great accuracy is necessary in locating the leak, to avoid unnecessary and expensive

digging and where the changes in grade are considerable. It is more common practice to ignore this problem on aerial cable.

13.05 A graph of pressure gradients plotted from the above data is shown in Chart 1. The vertical scale is in pounds per square inch and the horizontal scale is the number of minutes and shows the travel time between readings. This travel time approximately gives a measure of relative distances between valves. The data plotted is the average of the two readings at each valve. This averaging results in data that approximates what the readings would have been at each tested valve if all had been taken simultaneously. On such a graph the line between the two adjacent valves on each side of the trouble is extended in a straight line toward the trouble location. Where these two extended lines cross is the approximate location of the leak. If the times and pressures are accurately read and recorded and if the graph is accurately made, the leak location can be expected to be found within a few feet of the indicated location.

14. PRECAUTIONS

14.01 Nitrogen gas is neither poisonous nor exploxive. The atmosphere contains 78 percent nitrogen and 21 percent oxygen. Increase of nitrogen in a manhole by excessive escape of nitrogen used in testing the cable may create a dangerous situation by reducing the percent of oxygen below the amount required for respiration. Ventilation procedures should be used while nitrogen is being applied to the cable if the manhole is to be entered.

14.02 The nitrogen cylinders contain the gas at high pressure (about 2265 psi when full). They should not be violently struck, dropped, or placed horizontally where they can roll. When stored vertically they should be strapped so they cannot fall. They should be protected from fire which might heat them excessively. Their protective caps should be on at all times in the storeroom except when charging a smaller cylinder. It is suggested that the regulator be covered by a piece of canvas while gas is being injected into a cable.

14.03 While spray testing with water-concentrate solution the operator always should wear goggles or safety glasses. Dripping or spilling of the solution on pedestrians, automobiles and on painted surfaces should be avoided. If any solution drips on an automobile it should be washed off immediately with fresh water. It may give a false impression of color fading particularly if there is dust on the automobile surface.

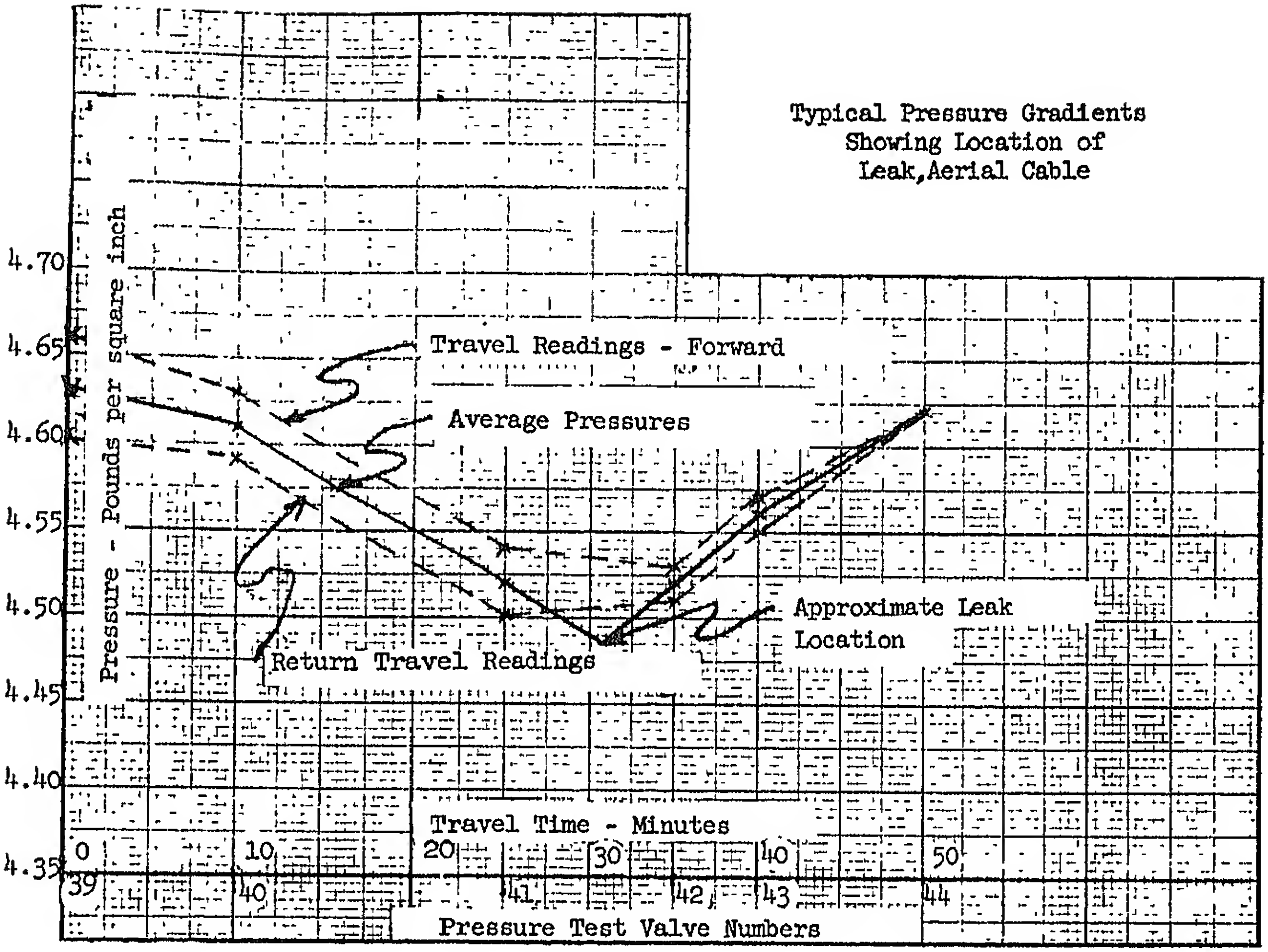

Typical Pressure Gradients
Showing Location of
Leak, Aerial Cable
Pressure - Pounds per square inch
4.70
4.65
4.60
4.55
4.50
4.45
4.40
4.35
Travel Readings - Forward
Average Pressures
Return Travel Readings
Approximate Leak
Location
Travel Time - Minutes
0
10
20
30
40
50
39
40
41
42
43
44
Pressure Test Valve Numbers

Chart 1

14.04 The concentrate for polyethylene sheath cable must not be the <u>type that will damage polyethylene</u>. (See paragraph 12.16) If the concentrate for lead cable gets on polyethylene cable it should be washed off immediately with fresh water.

14.05 The roll sprayer operator should wear rubber shoes and rubber gloves when working on cables on joint-use poles.

14.06 Extreme care should be used when placing and removing roller sprayer on strand to avoid contact with foreign wires.

14.07 The Fiberglas pruner pole should not be carried over the shoulder while the roll sprayer is attached to it. The sprayer should be attached at the work location.

14.08 Pliers or wrenches should not be used to open nitrogen gas cylinder valves.

14.09 The air compressor in a continuous flow pressurization system should not be allowed to run continuously to prevent overheating the compressor. About 75 percent of the time is a desirable maximum operating limit. If the compressor operates continuously it indicates excessive air leaks in the system under pressure which should be found and repaired.

14.10 Goggles should be worn when working with sealing compounds.

14.11 Persons using sealing compounds always should protect their hands by applying the Kerodex creams to their hands. (See paragraph 6.09)

Cost Estimate for Constructing Continuous Feed Air Pressurization on a Fifteen Sheath-mile Lead Sheath Cable System

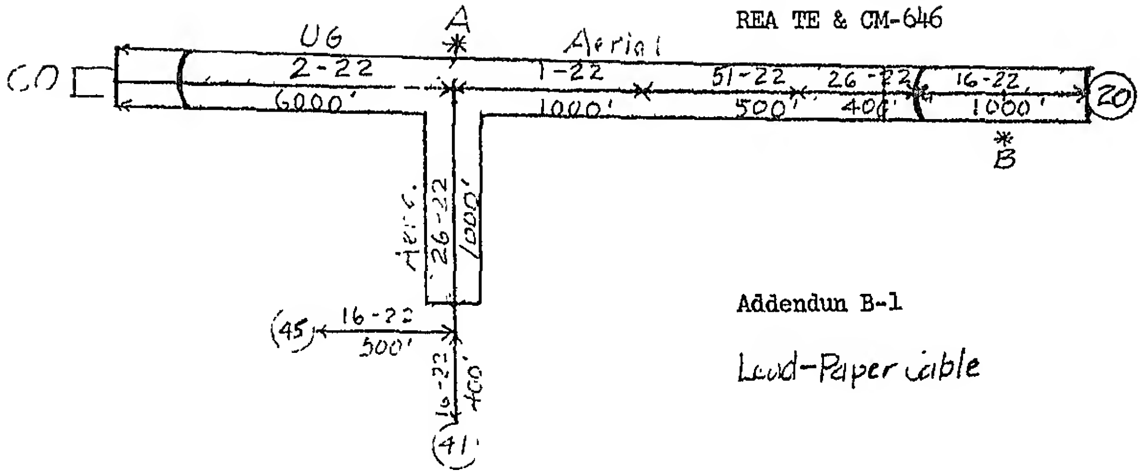
Central Office Equipment		
250 cubic feet per day compressor-dryer	$ 800.00	
Meter panel - 5 meters	150.00	
Polycor tubing - 20 feet @ $1.50	30.00	$ 980.00
Tools		
1/4 inch cable drill	$ 7.00	
3/8 inch cable drill	17.50	
C flange clamp	5.65	
B sheath lifter	2.60	
C pressure gun	17.00	
C adapter nozzle	4.00	
B cable core depressor	3.00	
B cleaning rods	1.15	
Orange sticks, package of 10	1.50	
Valve repair tool	.95	
B pressure gun holder	4.10	
Soldering form, 1-1/2 inch round	.95	
Spray testing kit	195.00	
C pressure testing gauge	33.00	
Pressure regulator	58.00	351.40
Materials		
C pressure flanges, 10 packages of 25	$ 32.50	
D pressure flanges, 10 packages of 25	50.00	
C pressure flange plugs, 10 packages of 25	20.00	
B pressure testing ells, 2 packages of 10	12.50	
Pressure testing ells, 2 packages of 10	11.30	
D sealing compound, small charge, 50	75.00	
D sealing compound, large charge, 50	162.50	
Lead lashing wire, AT6634, 1 1-1/2 lb. spool	2.00	
Alarm contactors, 8 @ $15	120.00	
C pressure testing valves, 20 packages of 5	60.00	
F pressure testing valves, 15 packages of 5	45.00	
By-pass valves, 12 @ $6.50	78.00	668.80
Labor on Above		
290 hours @ $3 per hour	$ 870.00	
Overhead, MV expense, and miscellaneous expense at $2 per hour	580.00	1,450.00
Total Capital Expense		$ 3,450.20

(Continued on next page)

Addendum A (See paragraph 2.02)

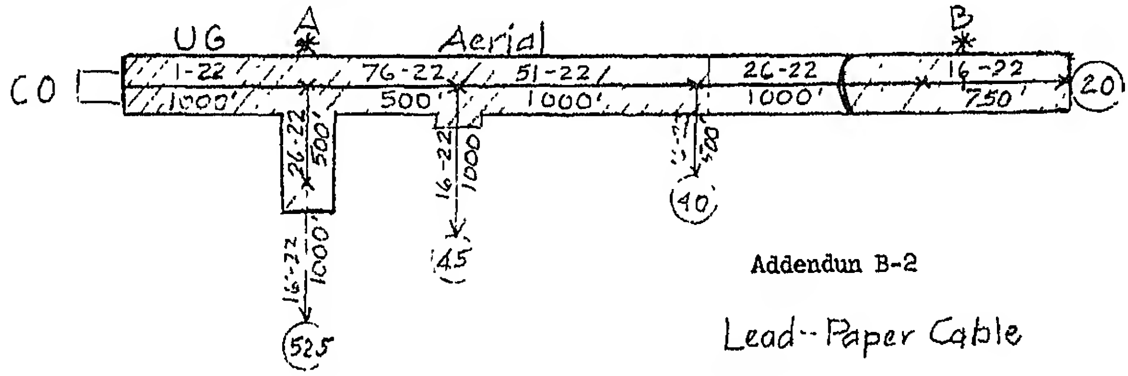
Maintenance Materials		
Cylinders of O. P. nitrogen gas, 224 cubic feet, 5 @ $50	$ 250.00	
C pressure testing concentrate, 48 bottles, 4 ounce	50.00	$ 300.00
Maintenance Labor		
240 hours at $3 per hour	$ 720.00	
Overhead, MV expense, and miscellaneous expense at $2 per hour	480.00	1,200.00
Total Maintenance Expense		$ 1,500.00
Grand Total		$ 4,950.20

Addendum A (Continued)



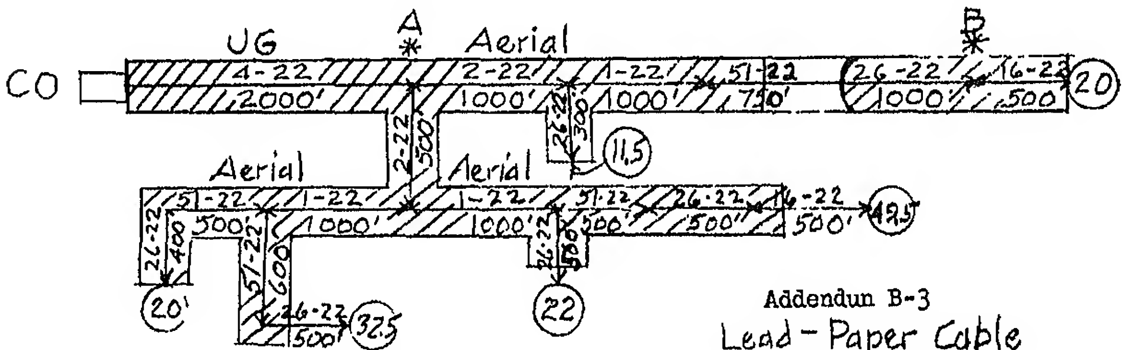
Addendun B-1

Lead-Paper cable



Addendun B-2

Lead-Paper Cable



Addendun B-3

Lead-Paper Cable

KEY

Note:
See Table 1 for Pneumatic Resistance Values

* Pressure Contactors

Definite Monitoring Range

Infinite Monitoring Range

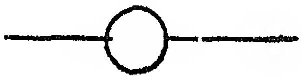
20 Total Pneumatic Resis. to End of Cable

TYPICAL LEAD CABLE PRESSURIZATION SYSTEM LAYOUTS

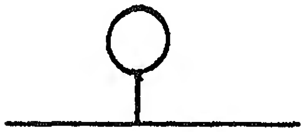
A. Letter Symbols used in figures shown below:

V - Pressure Testing Valve
C - Pressure Contactor
P - Pressure Testing Plug

B. Figures for Letter Symbols:



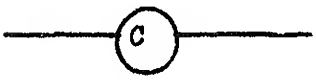
Used for Aerial Cable. If used on underground cable it indicates device is in manhole.



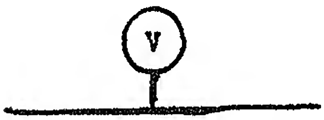
Used for underground or buried cable to indicate device is on a pedestal or stub pole or in a handhole adjacent to cable route.

C. Examples of Symbol Usage:

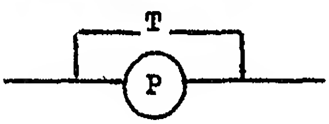
A valve on aerial cable or in a manhole on underground cable.



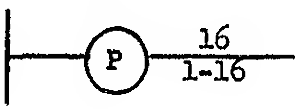
Pressure Contactor on aerial cable or in manhole on underground cable.



A valve on underground or buried cable but located on a pedestal or stub pole or in a handhole adjacent to cable routes.



A by-pass valve around a plug.



A plug in a terminal stub or a branch cable.

PRESSURE EQUIPMENT SYMBOLS